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WORKS LIST –INTERACTIVE PORTFOLIO *(trad. works list on reverse page)*

Click here (https://cbassuarez.com/labs/works-list) to view the works samples embedded as a PDF-synced portfolio; this list is powered by an open-source interactive package I developed called Praetorius, which intelligently displays scores and music. I encourage that you engage with the works through this format as it is a "one-click" environment.

For more information about the Praetorius package, please visit documentation at:
github.io (https://cbassuarez.github.io/praetorius) or npmjs.com (https://www.npmjs.com/package/praetorius)

Otherwise, you may find a traditional works list on the following page.

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WORK 1 – STRING QUARTET NO.2 "SOUNDNOISEMUSIC"
audio: https://drive.google.com/file/d/1MvkD4OY6-U9I9wFo4wsY5Ct_azAsfhRZ/view
pdf: https://drive.google.com/file/d/1LgROM7oe8Tc_bKaLxWGyqt4KykZVEBWD/view?usp=sharing

Description:
Heard melodies are sweet, but those unheard
Are sweeter; therefore, ye soft pipes, play on;
Not to the sensual ear, but, more endeared,
Pipe to the spirit ditties of no tone:
John Keats, "Ode on a Grecian Urn," lines 11-14

Every other performance, this piece is entirely improvised. Every other performance, the performers follow the through-composed score. Every other other performance, this piece is played at 80% intent and 50% rsentment. Every other other other performance, the members of this piece trade parts. Every 10 performanes, the members of the ensemble are playing a cruel joke on the composer and the audience. Every 12, the 5th page of every part is swapped for a page from one of J.S. Bach's Sonatas or Partitas for Violin. On any performance where it is the ensemble's second time performing that day, the music is to be read in retrograde inversion. Every peformance indoors must be done at double tempo. In the event that performers were not fed prior to performing, they may play noise whenever they may choose. If [redacted]*, the piece should be played in near-complete darkness.*

If you cannot tell the difference if you cannot beat 'em join 'em then does it even matter?
Listening instructions: *if pressed for time, please listen to the final page of music, starting at 10:30 in the recording*

WORK 2 – ORGANUM QUADRUPLUM "LUX NOVA"
video: https://www.youtube.com/watch?v=NSMiudJhIW4&feature=youtu.be

Description: There is a special quality to the kind of light that stained glass emanates which I find fascinating. Unlike traditional art, stained glass is an entanglement of light and material: the art is not the light, nor the glass, but the way the light conditions the space beyond which it occupies (a material declaration reminiscent of Fichtian dialectics or medieval anagogy; a sum greater than its parts). In this sense, it is not reflecting light but conditioning it, giving light a quality that makes its invisibilities visible.

Abbot Suger, in a historical reaffirmation of Gothic architecture, described this phenomenon – light passing through glass, which gives body and boundary to the invisible – as lux nova. Medieval builders saw themselves as material theologians: with the technological advancements of the Gothic period allowing for great windows, they could materialize theological truths through illuminatio, making light itself into an art that "corresponds" to celestial œuvres.

At the center is a dalle de verre slab, mounted to approximate free-free boundary conditions: edge-untethered, supported at nodal points, so the plate speaks in families of modes. As the bow excites the glass (in a lineage that runs from Suger's Saint-Denis and its program of lux nova to Le Corbusier's Notre-Dame du Haut with its deep-set colored glazing to Richter's pixelated Cologne Cathedral window), the bow draws breath, a sort of pneuma. These sounds are transmitted via transducer speakers to a ring of pianos which, even without hammer action, perform as a sort of telephoned organum: polyphony carried at a distance by transduction rather than shared air. In this way, the pianos act as armature and tracery, structures that bind.
Listening instructions: *if pressed for time, please listen to the middle section from 7:45-9:15*

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WORK 3 – AMPLIFICATIONS I. MARIMBAideefixe
album: https://cbassuarez.bandcamp.com/album/amplifications
video: https://scorefol.io/w/cm14gsu8n0000t8xthsxye1r9

Description: AMPLIFICATIONS – a series of improvised compositions, utilizing multiple pianos as resonating bodies to extend the sustain of various instruments. with various metal implements scattered throughout the piano bodies, the strings sympathetically reverberate along to the improvisatory sounds of each instrument, at times a whisper, at times a roar. microphones are placed inside the body of the piano capturing a large, harmonious reverberation, a ghostly chamber ensemble of one.

MARIMBAideefixe – *2 prepared pianos + 5.0 octave marimba with the marimba, i found that the pianos were quite receptive to many of the notes and harmonies i would play. even though the marimba is tuned to 442, or maybe because of it, notes would pop out and rattle metal discs and bells inside the piano, sometimes the same note, sometimes a more distant one. the marimba makes the pianos roar, swell to life, a sort of homunculus, a marionette. a bell swirls around inside the body of the piano, providing a rounded, tumbling ostinato. a ghostly chamber ensemble. i describe the track as an idée fixe as the main motivating phrase is such a focus of my playing. the piano seems to like it very well.*

A note about the (lack of) barlines: this piece is constructed in two voices which move independently. For this reason, barlines are modified to preserve the nature of the voices. You will see that, often, barlines do not match up until the end of a phrase. This might make more sense when listening to the recording. Visually, it aims to help the performer notice distance, silence, and the space between instances, where more traditional notation may not. The phrases played, though disjunct, are imitations of a baroque style, extemporized in a baroque fashion.

Listening instructions: if pressed for time, please listen to slides 8 and 9, which starts at 5:49.

Following page: writing sample – CONCERNING HUMAN UNDERSTANDING: The Case for a Radical Constructivist Approach in Music and Aesthetic Theory

CONCERNING HUMAN UNDERSTANDING: The Case for a Radical Constructivist Approach in Music and Aesthetic Theory

Sebastian Suarez-Solis

California Institute of The Arts

DMA Written Qualifying Examination

Tim Feeney

October 2025

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QUESTIONS

Our discussion regards the expression of a cybernetic approach to art-making.

I.

Using the writings of theorists including Mead, Glasersfeld, Glanville, Masani, and/or others, articulate a theoretical and historical framework for thinking about the cybernetic. How do concepts such as recursion, self-reference, eigenform, the second-order, and an investigation of the position of the Subject, define a cybernetic approach to discussing an artistic practice?

II.

You have identified the work of a few artists, in particular the Icelandic-Danish intermedia artist Olafur Eliasson, as emblematic of the issues surrounding an approach to cybernetic art making. With reference to Eliasson's work, and supported by reference to other historical artworks, discuss the challenges in applying an objective cybernetic theory to the subjective work of artmaking. How well do these artistic expressions engage with your theoretical model? Is there an example where this thinking has influenced your own work?

ABSTRACT

Second-order cybernetics, as defined first by Mead and von Glasersfeld – and contemporaneously by Glanville and Masani – provide useful constructs by which we can measure artistic events when applied to the artistic realm. Over the last 100 years, artists have used cybernetic concepts to further artistic mores, akin to scientists' findings generated from the scientific method. In the mid-20th century, we observe Nicolas Schöffer attempting to join cybernetics and spatial arts in the first proclaimed cybernetic artwork CYSP 1; in the late 20th century, Eduardo Kac and Ikuo Nakamura's Essay Concerning Human Understanding explores a rhizomic exploration of the relation between animals and plants through lab-like experimental conditions, and; in the 21st century, Olafur Eliasson uses mediums like monochromatic light, color filters, mirrors, and optical components to explore mood, perception, and behavior within the self.

Texts from Kollias, Masani, Mailman, Scott, Scholte, and Shanken help elucidate methodologies by which one may analyze the referenced artworks either in a cybernetic manner or as cybernetic artworks themselves. However, it is inconclusive as to if such a research methodology will pertain to art and artmaking; moreover, a wholly-objective cybernetic assessment of art and artmaking is not necessarily pertinent to cybernetics nor artmaking, as some referenced radical constructivist writings show. That is to say, a radical constructivist view of cybernetic artmaking does not necessarily require objective metrics.

The concepts of the subject and the eigenform, both classical concepts in the field of cybernetics, provide meaningful points of reference – of subjectivization, as the act of referencing implies a subject – to apply to artistic works, as applied in this paper to the works of

the artists mentioned above. Philosophic constructs of techne, phenomenology, and immanence also aid in this task.

keywords: second-order cybernetics, eigenform, immanence, self-organization, cybernetic art, radical constructivism.

CONCERNING HUMAN UNDERSTANDING: The Case for a Radical Constructivist Approach in Music and Aesthetic Theory

Introduction and Historical Context

> "We have come to believe that the old hierarchies of power can be replaced by self-organising networks. From internet utopianism to the global economic system, and above all, the ecosystems of the natural world. Today we dream of systems that can balance and stabilise themselves without the intervention of authoritarian power. But in reality, this is the dream of the machines."
>
> – Adam Curtis, *All Watched Over By Machines of Loving Grace*

In the first moments of the award-winning 2024 computer horror game PROXIMATE, the player is thrust upon a mission to retrieve sensitive information from a remote substation with this message: "*Congratulations, contractor! You've been approved to trial our cutting-edge AI visor."* This AI visor, a proprietary technology which senses proximal data, makes a decision about what is orthogonally in front of the player and serves them that information. It is the only way they can navigate throughout the rooms of the substation in the game; there is no other visual interface for navigation and ambulation.

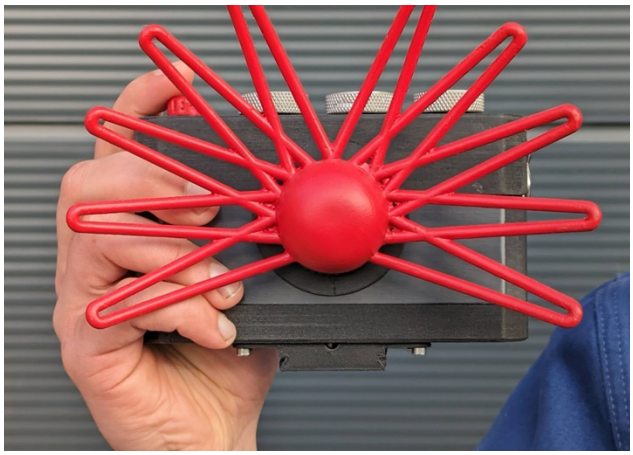

Figure 1The Paragraphica, designed by Bjørn Karmann, which takes an image of a scene and then outputs an AI-pwered description. Photo by the creator.

In reality, we already have items like the visor described in the PROXIMATE:

Paragraphica (right), a camera which, upon snapping a photo, returns back only a prompt of what it sees, and tools like Envision AI, which sees and speaks out visual information to the user. Over a short amount of time playing through PROXIMATE, players learn to use their included map and navigate their way through potentially contaminated areas in the (perceptual) dark – that is, until their map is deleted in order to preserve space, after which, for the rest of the game, they are forced to interface with the game through only one mode of interaction. They are forced to blindly learn the layout of the rooms, even with dangers present, through perceptual feedback alone; this "map-in-their-mind" ability, in a way, is a self-organizing system that the user constructs.

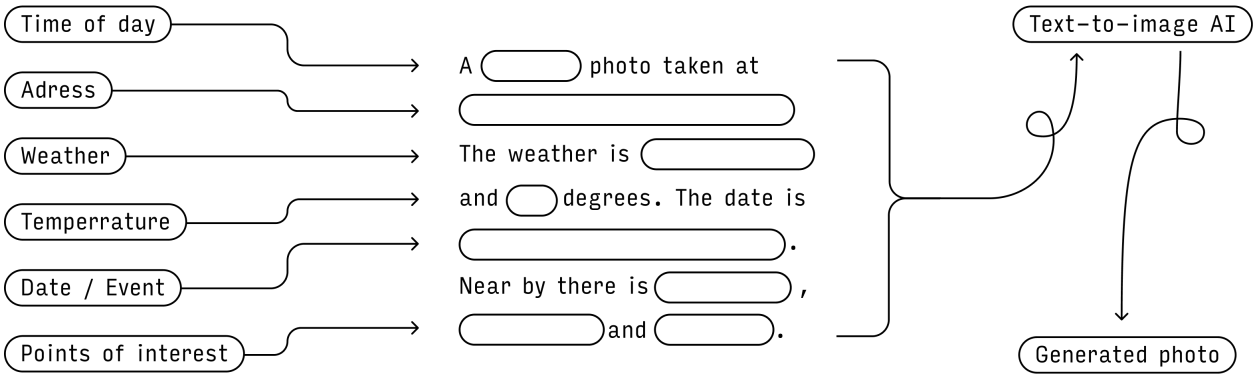

Figure 2 The simplified layout, mapping out an optical I/O list that resembles cybernetic systems. In this configuration, the user is involved in a first-order cybernetic system.

Over time, and through continuous trial and error, the user learns to navigate the map in the dark. That said, the visor, itself powered by a feedback network of data comprising an LLM, is only as confident as the signal it receives and, even then, can be shaky through no fault of its

own (e.g. “Woman – 44.47%” or “Ketchup – 95%”)[1]. It is only a prediction engine and, understandably, in low-light conditions, it might not see the necessary markers of information it needs to be as confident as it should (or, conversely, it might see something that makes it very confident in what it is seeing).

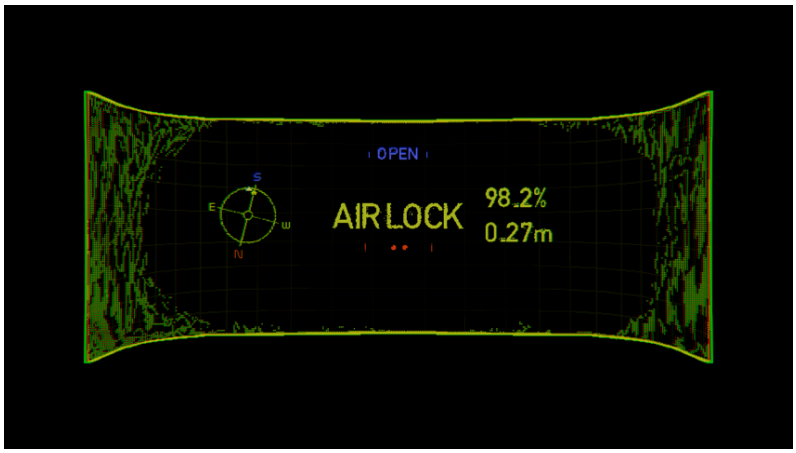

Figure 3 The main view in PROXIMATE.

Thus, the player inevitably learns from self-instruction, unpacking a set of steps that span an entire game over little more than a couple lines of instruction. More than anything, the player is correcting, testing spatial hypotheses iteratively, recursively until they reach the correct area, then doing the same thing, but in reverse, to reach their home base, the airlock, the only place where they might see a map of where they need to go. [2] Here, the mechanism is apparent to the audience primarily of how noisy the mechanism is (how lossy it is): the player likely knows the ketchup is blood despite the 95% confidence, and has learned that by rote because of how wrong the visor tends to be.

---

[1] This is consistent with Norbert Wiener’s claim that “information is the measure of organization” but that noise is its inevitable companion (*Cybernetics*, 1948, p. 25).

[2] Ashby’s *Law of Requisite Variety* (1956): systems survive by matching internal complexity to environmental unpredictability.

Aristotle asserts in *Nicomachean Ethics VI*: “we deliberate not about ends, but about the means to ends”. PROXIMATE reaffirms this assertion through its visor element; while the player may be prima facie concerned with reading an inaccurate system to nonetheless commit to decisions of morality, the ultimate aim of the game is presented during the portions where the user is navigating blindly around the map. This irony sounds an Aristotelian double-bind: you cannot trust your faulty visor, yet you must use it to make decisions. “Your visor says that the red stain on the wall is ketchup. It was coded by some very smart people, so you should definitely trust it.”[3] Despite their doubts, to the player, the visor and reality are one and the same; they cannot take the visor off and check. Any player with a survival instinct will know not to trust any other sounds, but otherwise, there is no other input.[4]

Epistemically, the player acts in ways that affirm their survival through self-reference in an act of conatus[5] imbued upon the map. The player is placed inside a system which gains knowledge via ascertainment of data by the player at various sites along the map; they are tasked with this ascertainment of data despite a lack of physical vision, so they must preserve themselves through perception and rationalization, an enactment of Spinoza’s mind-body monism.

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[3] Maddox, Cain. *PROXIMATE*. Released November 8, 2024. macOS, Windows.

[4] Spinoza, *Ethics* IIIp6: “Each thing, as far as it can by its own power, strives to persevere in its being.” In PROXIMATE, this is applied to the player, yes, but as well as the (ex-)crew onboard the substation and the unknown creatures currently inhabiting it.

[5] Effort, or striving, using by Spinoza to illustrate the divine effort of every human soul to self-affirm and persevere.

In *Ethics II*, Aristotle posits that "he who has a true idea knows that he has a true idea. " Here, any sort of "true idea" collapses into a degradation of the form; there is no way for the player to truly know what they see, and as such they must trust or distrust the visor output. Husserl, in *Ideas I*[6], wrote that perception is always mediated by superseding structures, such that there is no raw output. That is to say, perception is lossy: if ideas, wherever they come from, are a raw output of thought, that output is always degraded by some sort of mediating structure(s). These can be physical parameters, like temperature and distance, or they can be artificial or social parameters. This lossy quality to perception is a mainstay of PROXIMATE, forcing the player into a temporary loop wherein each movement redefines the user's memory and construction of space**.**

On the other hand, if this lossy quality is an inherency to our perception, we might simply decide to accept it as a condition of our invention. The visor does not condition the player's reality, it is the player's reality. In this case, the visor's materiality is an illusion – there might as well be nothing "on the other end", yet this game elicits quite the compelling response according to reviews, so it would be hard to believe most players are not immersed by the experience; this illusion of materiality is true for us as well as the player-character. The player has no idea whether their character is really witnessing what they are or are whether or not they in a completely different setting[7] (or rather, the player-character has no idea if what they are seeing is

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[6] *Ideas I* §83–88

[7] I mean this practically, *setting* as in another part of the map, as well as a less local context (a completely different setting, per se). For all the player and the player character know, the visor could very well be enacting a simulation upon the player character.

real, nor presented with any other method by which to check their reality), just as much as we cannot know for sure what the player character is truly seeing or experiencing. Even as such, we accept that what we see in front of us is real: “the environment as we perceive it is our invention. von Foerster (1953)”

Early cyberneticists knew this fundamental notion about perception and human cognition; they posited that reality, due to its intractability with the observer, is what the observer wills it to be. Scientific philosophers, systems analysts, computer scientists, and intellectuals of many fields formed the ranks of the first-wave cyberneticists around the late 1940s. Cyberneticists like Heinz von Foerster established the very same frameworks which systems like PROXIMATE act upon, borrowing the ideals of Hume, Husserl, Hegel, and Heidegger. To cyberneticists, the world is like PROXIMATE: a series of inputs which, as a totality, define our reality, sometimes with a user that acts as a part of that system.

In either case, the user must learn to mediate the system through repeated iteration and self-adjustment.

Cybernetics as defined by its architects

Cybernetics has its roots in the immediate postwar period of the mid-Twentieth century and the handful of years beyond that time. Two key elements stand out as vital proving grounds for cybernetics as a doctrine: the paper *Behavior, Purpose and Teleology* published by Norbert Weiner et al, which is among the foundational texts of the field, and; the Macy conferences, a series of conventions on the unification of the sciences put on by the Josiah Macy Jr. Foundation which is remembered for its series of conferences on cybernetics. Key figures include Margaret Mead, Norbert Weiner, Ross Ashby, and Jay Forrester. A philosophical science, the aim of cybernetics is to represent reality as a set of functions, showing a network of relationships

constructed through logical bases; that is to say, cyberneticists work to represent reality as a series of inputs, viewing it as a recursive loop that self-stabilizes.

This mode has been a dominant mode of representation in all scales of the societal production of space since the mid-Twentieth century. Cyberneticists influenced telecommunications companies, research and computer labs, military and governmental network experiments, and other institutions. For example, the ARPANET project, the military-funded precursor to the modern-day internet, drew heavily from cybernetic research.[8] J.C.R. Licklider, computer scientist and cyberneticist, drafted several papers outlining the graphical user interface and the ARPANET. [9] In his papers *Man-Computer Symbiosis and The Computer as a Communication Device,* Licklider essentially outlines the structure for ARPANET, which he used to secure funding for its construction. In a not-so-roundabout way, the world owes much of its modern comforts (and discomforts) to cyberneticists.

It follows that there is then cybernetic influence along other planes of being, including artistic expression – art and artmaking. There is such a thing as expressly cybernetic art, as well as art that may be viewed as inheriting cybernetic properties. The following paper is an

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[8] Roberts, L. G. (1967). *Multiple Computer Networks and Intercomputer Communication. Proceedings of the ACM Symposium on Operating Systems Principles,* 14–19.

Licklider, J. C. R. (1960). *Man–Computer Symbiosis. IRE Transactions on Human Factors in Electronics,* HFE-1(1), 4–11.

Licklider, J. C. R., & Taylor, R. W. (1968). *The Computer as a Communication Device. Science and Technology,* 76(4), 21–31.

[9] *Ibid.*

exploration into whether that structure serves us as artists still to this day, and what can be done with such constructs.

Explanation of terms

To facilitate a clear and thorough discussion about cybernetics, and because these terms are used in varying disciplines with varying perspectives, we must discuss the following terms along a narrow set of definitions.

Phenomenology, as used in artistic critique by Merleau-Ponty[10] is defined as the study of perception before any material constructs of interpretation are applied to raw intellect, before any mediative constructs like theoretics; in this way, phenomenology is concerned with a subject's (or, more aptly, an observer, in this case) perception or observation before their participation in any system. If viewing raw intellect or raw perception as a whole which mediating substrates like interpretation necessarily degrade, then phenomenology is concerned with perception as it occurs prior to this degradation.

Techne (τέχνη) as used in artistic critique by Heidegger[11] is defined as "not only handicraft manufacture, not only artistic and poetical bringing into appearance and concrete imagery… a bringing-forth, *poeisis*." This is the embodied knowledge or craft of production — the procedural intelligence by which understanding arises through making and manipulation of materials or systems.[12]

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[10] Maurice Merleau-Ponty, *Phenomenology of Perception* (1945);

[11] Martin Heidegger, "The Question Concerning Technology" (1954)

[12] Artistotle describes this in Ethics VI as "a state concerned with making, involving a true course of reasoning" WD Ross translation page 142

Immanence as coined by Spinoza and Peirce[13] is defined as the condition in which the processes of thought, life, and causality unfold within the same continuous reality, without appeal to external or transcendent principles.

First-order cybernetics, as defined by von Foerster in Cybernetics of Cybernetics (1971) is "the study of observed systems," that is, systems as they appear to an *external observer*. Second-order cybernetics is "the cybernetics of observed systems" or equally *the cybernetics of cybernetics.* These systems include a mutable, internal observer**.** Systems, by definition, are representational models, meaning we can chart them, or describe them through a series of formal logics. As Jay Forrester, pioneer cyberneticist and systems theorist, explains,"[we're] just part of a system. That is anathema to many people because they like to think of us as people, as independent, but basically, they are driven in most of their actions by feedback loops, which means physical systems, electrical systems, social systems, political systems, biological systems, internal medicine, medical systems of the body. They are all fundamentally networks of feedback loops."[14]

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[13] Baruch Spinoza, *Ethics* II. Prop. 7; Charles Sanders Peirce, "Evolutionary Love" (1893)

[14] Curtis, Adam, dir. *All Watched Over by Machines of Loving Grace*. Episode 2, "Chapter 2: The Use and Abuse of Vegetational Concepts," written by Adam Curtis, with Adam Curtis, David Attenborough, and Richard Dawkins. BBC, June 6, 2011. 59m.

Integration within an artistic context

There are several contemporary authors who have taken it upon themselves to translate this doctrine into an artistic scope; this is not inviable, as the visual and sonic arts to some degree slot well within the ideological confines of cybernetics. For instance, Licklider himself made significant strides in psychoacoustics. These realms were connected, even from initial stages, such that transference between either were not only expected, but recursive elements that feed back upon each other. Masani and other realist theoreticians back this up through the acknowledgment of scientific progress as a continuous dialectic (Masani 1994).

Phenomenology is itself a relevant term in art performance, prior to any cybernetic oeuvres. It has been used in modern critique to encapsulate a wide range of experiential positionalities. Along these lines, the artworks covered (Eliasson, Kac and Nakamura, Schoffer) serve to enact an aesthetic immanence analyzed through the lens of second-order cybernetics.

While the ideas of self-balancing systems, systems of order, recursion, and the Subject have been prevalent in modern society for much longer than the last two centuries, those notions as they pertain to cybernetics only become useful to our discussion after around 1950 or so (after the concrete foundations of cybernetics begin to take shape). Though any artwork might be analyzed from a cybernetic lens, and while a cybernetic critic could possibly further argue that one, some, or most artworks are structured through cybernetic method, didactically it is most pertinent to limit the scope of what we might consider cybernetic art to these three definitions, from strongest to weakest:

1. Artworks explicitly stated as cybernetic artworks, or artworks which bear significant association to cyberneticists or cybernetics enough to consider them de facto cybernetic artworks despite the absence of any such prescribed designation

2. Artworks created after 1950 which could exhibit tendencies embodied in cybernetics, as defined by lead cyberneticists of the late 20th century
3. Artwork in general, if we view art as encoding some sort of cybernetic method or framework.

As most of our discussion concerns itself with artworks after 1950, it is best to begin our historical account with the explicit beginnings of cybernetic artworks at the turn of the Twentieth Century and not with any artworks that might fit within our third category. [15] While there are certainly artworks which embody (what we would now call) cybernetic thoughtspace that were created before the conception of even first-order cybernetics (and without making the very easy cybernetic claim that every or most artwork, by virtue of being a human output created by a

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[15]In this sense, *Fortspinnung* – both as the phenomenon being theorized (describing the Baroque period) and the theory itself (set out in 1915) – can be seen as a cybernetic process, for several reasons, chief among which being its generative nature, which *spins forth* from a central motive. As such, voices, coming from an initial position, must move along a set code of musical rules, and one voice's position affects all voices both forward and backward in time (e.g. a leading tone in one voice might need a certain approach a couple beats before and after), which might be seen as self-regulation. Recursive elements may also be present in these works (e.g. episodes in a fugue or imitative entrances). However, this definition of cybernetics is, for the most part, not pertinent to the scope of this paper, as it is largely an inference tool useful for cybernetics-based critical studies; these inference tools are useful, but they are not the function of cybernetics which pertains to artmaking. Inasmuch, the most useful inferences in this realm come from artworks fostered by or created after the dominance of cybernetic thought.

cybernetic-like neuron-networked mind, is inherently cybernetic), it is most useful to discuss mainly the artworks that fall into our first two definitions of cybernetic artworks. It is thus, in this search for the first described cybernetic artistic byproduct, that we arrive at Nicolas Schöffer's cybernetic practice in the early half of the Twentieth Century.

Historical applications of Cybernetics in Art

Nicolas Schöffer, along with his work CYSP 1, is known for creating – by proclamation – the first explicitly cybernetic artwork (that is to say, the first cybernetic artwork created specifically to be a cybernetic artwork; in this sense, this work is already exhibiting second-order properties). This creation – CYSP 1 (1956), short for *CYbernetic SPatiodynamic* – is a confluence of light, shadow, and form, but in physical, real-world terms. Light and shadow are physically created and harnessed in this spatiodynamic sculpture; polystylistic in nature, it could be a piece for solo dancer one day and mounted on a car as a moving installation the other. At its core, it is a set of blocks, jigs, and lights that form a kinetic sculpture; the work, crafted with direct support from engineers at the Dutch consumer electronics corporation Philips, reacts to the world around it, through autonomous motion of its many plates about several axes and through a rigid feedback system enabled via the use of sensors which change the sound, color, and light output of the machine. In any case, the discussion of explicit cybernetic artworks begins here.

Figure 4 Schöffer's CYSP 1, the first cybernetic work by proclamation as such. Photo taken from http://dada.compart-bremen.de/item/exhibition/3

By the mid-90s, with the rise of Silicon Valley startups and their new adoption of cybernetic principles, the playing field had changed, and the musical and artistic landscape reflected that change in content and form, though its frameworks remained the same. In other words, cybernetic artworks of the time, now benefitting from decades of research and conceptualization on the theoretical front, reaffirmed the cybernetic ideal through their continued search for the balanced, recursive system of changes, their treatment of the Subject, and their use of machine technology facilitated by/facilitating human interaction; however, aesthetically and materially, artmaking had progressed to better reflect these ideals as they were seated within the collective unconscious at the moment. This would be most apparent in the use of emergent digital technologies, inter/intra-net telephony, and refinement of the usage of analog telemetry and signal processing equipment like sensors, photometrics, etc. No more apparent of an

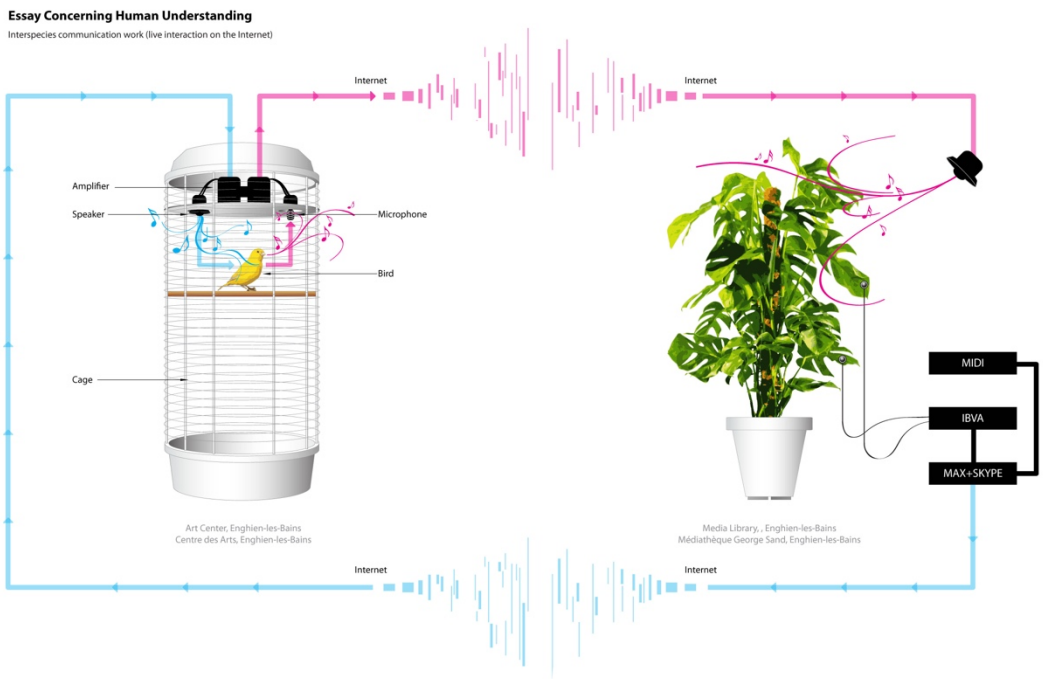

Figure 5 A feedback diagram exploring the nodal cybernetic maps which underpin Kac and Nakamura's Essay Concerning Human Understanding. Photo by the artists.

exemplar of this change in methodology is Eduardo Kac and Ikuo Nakamura's *Essay Concerning Human Thought,* a cybernetic work exploring action at a distance through an early exploration of networked systems and computer sonography. Carrying a cybernetic lens even through its methodology, the work is structured as a form of sonic experiment – equal parts art and inquiry – instead of the purely structural or material concepts that early cybernetic artworks effused.

Described as a "live, bi-directional, interactive, telematic, interspecies sonic installation" (Kac and Nakamura 1994), the work can be viewed in these two concepts described above. As an artistic endeavor, it can be described as such: it is an installed performance which, over the course of its installation, explores a recursive loop at a distance between a canary and a plant. As the canary sings, the sounds are sent over the internet (then an emergent technology, only a handful of years divorced from its ARPA-NET origins) to a plant over 600 miles away, whose electrical impulses are analyzed and transformed to MIDI information which is inversely relayed back to the bird. As a cybernetic inquiry, this experiment explores the actions by which a recursive system may be stressed, or the stressors which may excite cybernetic systems into or out of certain modes. As the bird sings, the plant is affected, even if a small amount. Any small change in the system is amplified over time. Human interaction, Kac and Nakamura found, exacerbated this. In any case, this work, landing squarely in first category of definitions of the term "cybernetic art", is a definite touchstone for second-order cybernetic artworks.

Around the same time, artist Olafur Eliasson was burgeoning a new studio laboratory in Berlin dedicated to spatial research through artmaking. It is through his work at Studio Olafur Eliasson that the artist created a large body of spatial works in what can largely be seen as a cybernetic oeuvre. As such, a large portion of this paper is scoped to discuss his body of works,

namely a subset composing three main categories, labeled by their use of any one or several particular material(s):

1. Mirrors
2. Monofrequency [sic] lamps, as Eliasson himself describes or, more specifically, low-pressure sodium light
3. Colored light and shadow

Starting with the first category, the "mirror" works include objects like *Self-Loop* (2015) and *The Listening Dimension* (2017). These works are notable for their creation of an extended self-perception; with these works, Eliasson's exploration into the extension of the perceptual senses is at its most terse, this sense of perceptual exploration being at the forefront of the installations experiences'. In both of the selected works, the aim is to create a space with the mirrors which seems impossible: either to let you see yourself from a vantage point from where you are standing – as in *Self-Loop* – or to create a circle which "clips" through to the outside of the gallery walls. At the core of this exploration a careful balancing of the notion of the "subject." Eliasson's acknowledgment of the audience in these works is a central facet to cybernetics in its veneration of the Subject. In classical cybernetics, the Subject is treated as the principal operator by which operations to the systems matrix are performed; in this sense, they do not just witness the system take place, they are an active participation in the process, reacting and altering the possibilities, variables, and conditions by which the system operates. Eliasson's treatment of the Subject through his works is eerily reminiscent of this conditional operation outlined by cyberneticists like Jay Forrester and Margaret Mead.

To some extent, a material analysis is warranted here. Eliasson, throughout his body of work, extensively chooses materials which are minimal and base, carrying a semiotic minimum

friction to the transference of an artistic ideal, whatever that may be for the art piece in question. In other words, the form follows function, where a material choice is made for an artwork only insofar as that material can be decoupled from its associations and, unburdened by metonym, act as an empty vessel for the physical phenomenon that Eliasson wants to exploit in that work. For example, the lamps in his mono-frequency works are not the artwork, the mono-frequency light is. In a similar recursive capacity, the lights can be viewed as a metonym for the actual residence of the artistic essence or kernel: the feeling of monochromy and how that interacts with your localized range of photosensitivity. For the most part[16], Eliasson steers away from any wholesale adoption of any material's semiotic markers. As such, metal, for example, as it is used by Eliasson in his body of works, does not feel[17] cold or hot as some might imagine, but it just exists as a neutral object prior to any association, if it is even noticed at all.

Another material by which Eliasson fashions an oeuvre is light. Most famously, Eliasson has used monochromatic light from low-pressure sodium ballast bulbs to create otherworldly effects. His use of mono-frequency lighting from low-pressure sodium lamps has been a mainstay of his career, most famously with the exhibition of his *The Weather Project* at the Tate Modern in 2003. Most notable for its use of approximately 200 mono-frequency lightbulbs arranged in a semi-circle so as to mimic the sun, the piece also utilizes a large mirror placed atop

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[16] Other works like 'Die Dinge, die du nicht siehst, die du nicht siehst' (2001) have a more traditional relationship between materials and their construction, with materials retaining (and relying on) some of their post-essential semiotic associations.

[17] The perception would occur within the Subject's mind, as an interpretation of the artworks placed in front of them.

the gallery, affixed to the ceiling. In this sense, it is a confluence of his light and mirror-based works. However, Eliasson has quite the few works beyond *The Weather Project* that utilize (polychromatic and monochromatic) light, including two other monochrome works which will be a focus of this paper: *Room for One Colour* (1997) and *The Unspeakable Openness of Things* (2018).

The last category of works belies a new mode of creation for Eliasson, colored shadow and light. These set of works, emerging in the latest decade, show a continued commitment to the extension of perception by the artist, creating new subjectivities by which people can interact as subjects in a cybernetic system.

Now, a reader might wonder what exactly cybernetics has to contribute to these artworks or, rather, where the directionality lies between cybernetics and artmaking. Yes, even if one accepts cybernetics being among the dominant modes of contemporary thought, it is rather a leap to create assertions – encroachments – upon arbitrary conditions as to whether a work is cybernetic or not. However, when we take a radical constructivist point of view and apply it outwardly, we find that the second-order cybernetic viewpoint is axiomatic. By nature, second-order cybernetics is conditional. In this way, the cyberneticist views these theoretical encroachments as a series of conditions or if statements; here, the radical constructivist cyberneticist says *if this work is cybernetic, then* . . . and achieves recursive conclusions based on that rational output.

Research Question and Methodology

It is thus that we arrive at our research question: is it possible to form a unified, objective methodology by which to interpret art and artmaking using second-order cybernetics and, by corollary; to what extent is second-order cybernetics to art and artmaking? This is a question

that, in one form or another, has eluded cyberneticists for the latter part of the twentieth century, namely due to the schism between realist and radical constructivist views within the field; objective and subjective approaches within cybernetics have been historically opposed, with the former using quantitative methodology to map models of feedback, recursion, and systems of balance, and the latter achieving the same through axiomatics. While this paper acknowledges the advances of the realist cybernetic framework, to ground these arguments in musical and artistic foundations, a subjective, constructivist approach is warranted. Therefore, there will be no grand unification of the objective and subjective modes, but rather an interrogation of recursive systems, definitions, and modes of thought as outlined by constructivist second-order cybernetics and how they might integrate with the artistic.

As cybernetics is also a historical movement, a historiographical account of cybernetics as it pertains to art is important to acknowledge as a primordial layer of thought prior to creation. As a dominant mode of thought (albeit many times unspoken, unnoticed, or not acknowledged), cybernetics systems have been at the heart of contemporary artmaking for the greater part of the last 50 years. In this sense, as cybernetics formed alongside the rises of neoliberalism, the idea of the balanced system – the decentralized, wholly-democratic system that patches itself – can be seen as a uniquely modern idea. It is then safe to assume that contemporary experimental artmaking is downstream of (among other things and possibly less and less so per day) cybernetic thought. Thus, a material acknowledgment of this lineage is necessary for any sort of critical artistic introspection.

Methodology

For the most part, this paper is structured as a series of case studies centered around artworks which embody cybernetic practices. Works introduced previously by Eliasson, Kac and

Nakamura, Schöffer are expounded upon as potential touchstones for cybernetic output in the arts, with a practicum by the author as a reflection of these case studies. While much of the paper is devoted to exploring Eliasson's body of work as a unitary cybernetic output, smaller case studies into other artists provide a fuller picture into the realm of cybernetic art and cybernetic approaches to artmaking.

Aside from the inquiries into particular artworks, this paper also relies on theoretical and philosophical approaches to discussing second-order cybernetics. These approaches are present in the use of real technical frameworks borrowed from cybernetics. In this case, I use cybernetics to explain cybernetics[18], a recursive output indicative of second-order thinking.

This methodology proved more than suitable as a recount of cybernetics and as a method by which to integrate cybernetics and artmaking. Further, more practical approaches to conducting research in this field may definitely prove useful in gaining concrete data points or creating cybernetic schematics. However, it is outside the scope of this paper to employ any of the more realist cybernetic approaches to methodology, for the following reasons:

1. Lab-grade equipment is not available or readily accessible

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[18] This acknowledgment is reminiscent of the concept of self-hosting in low-level computer programming. Self-hosted programs produce new versions of themselves, often used for compilers; self-hosted compilers, for example the C compiler, are compiled using their own language. That is to say, C compilers are built in C. A similar process happens in zip encoding. In using cybernetics to explain cybernetics, I engage in a similar self-hosted packaging of information.

2. Access to such equipment for telemetry, testing, modeling, or simulation would be expensive
3. The same point can be made, or at least initiated, without large scale hard measurements.

This methodology is not without its challenges, however. There are two main problems at this junction; though we have chosen to remain strictly within the confines of constructivist cybernetic thinking, primarily, we face the nominal issue of any axiomatic theory – its axioms must map to the real world to be useful in the real world. That is to say, axioms are useful inasmuch as they lead us to new modes of thought, but they are constructs which necessarily exist as such. They exist in thought-space. This is important because, as a theory, cybernetics may be useful but realistically might not map to any real-world phenomena. This is most evident in the notion of the *ecosystem*, which is an extant cybernetic concept.[19] While the concept of a self-organizing system has existed in modern society for centuries, the notion of a scientific theory of stasis is a uniquely cybernetic concept. To think of society as a series of arrows (think predator/pray food maps) – a giant feedback loop which establishes homeostasis through population changes which can be mapped through functions – is to think in cybernetic terms. However, these relationships between populations tend to diverge instead of converge, with most populations trending toward eventual decay and dissolution rather than converging towards a

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[19] Curtis, Adam, dir. *All Watched Over by Machines of Loving Grace*. Episode 2, "Chapter 2: The Use and Abuse of Vegetational Concepts," written by Adam Curtis, with Adam Curtis, David Attenborough, and Richard Dawkins. BBC, June 6, 2011. 59m.

fixed point. In this way, constructivist, second-order cybernetics fails as a model for real-world dynamics. As such, we must be strict, narrow in our definitions, and careful with the conclusions we draw. Our second issue we face when mapping second-order cybernetic concepts to artistic critique, without any rigid structures like data analysis, telemetry, psychoacoustics, etc. with which to bind our arguments, it might be harder to make any specific claim about elements of recursion, feedback, and deference of the Subject. Because of this, any sort of artistic claims made on a cybernetic basis in this paper are done strictly through a constructivist lens. That is to say, it is important to note that none of the claims made about the cybernetic nature of a piece re: perception or any neurological bounds which we do not have the requisite tools to diagnose correctly are definitive. They are made purely on axiomatic bases derived from the established structures of second-order cybernetics as set out by Forrester, Mead, Glanville et al.

A second section aims to bridge the gap in methodology by expounding on a practicum by the author. This practicum is an artistic exploration of the research set out by this paper (and as such, in true cybernetic fashion, the practicum references this very paper and, therefore, itself!) output as a spatiodynamic installation using monofrequency lighting. The practicum is a work titled CONSTRUCTIONS and was premiered at The Wild Beast at California Institute of the Arts on April 16, 2024; it consists of a set of six kinetic light sculptures incorporating incandescent, LED, and low-pressure sodium light, as well as an eponymous chamber symphony for solo percussion and 4 light switchers performing on networked relays. These networked relays are smart switches which act as ON/OFF gates for the light sculptures, which are effectively played as instruments during the concert portion of the installation.

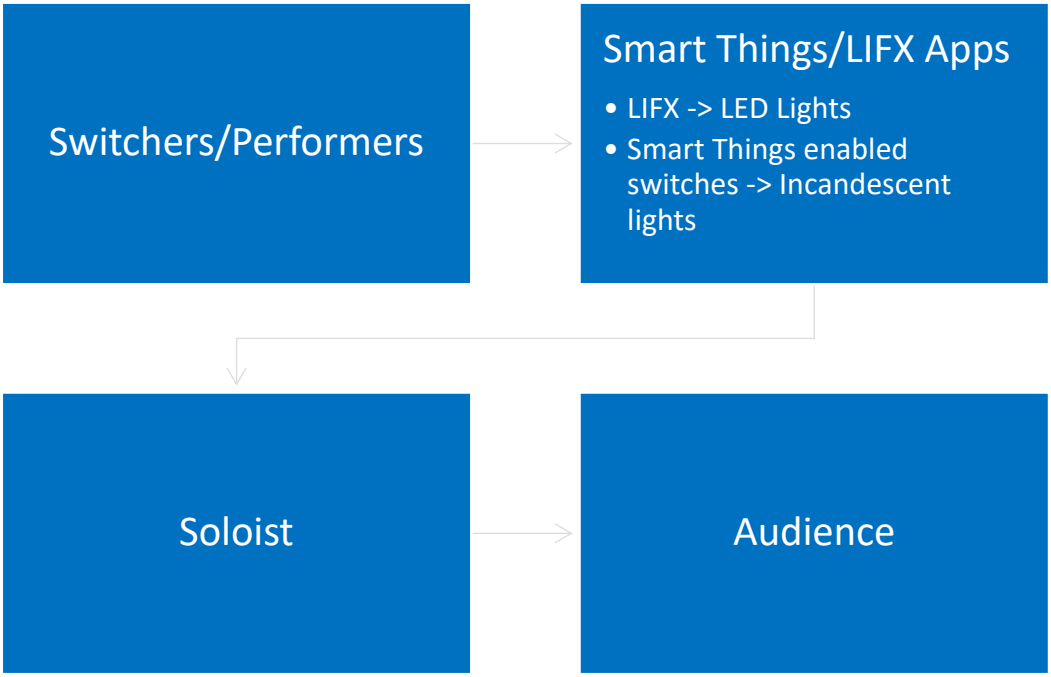

Figure 6 A cursory overview of the cybernetic hierarchies/nodal configurations of CONSTRUCTIONS (2025)

In undertaking such an endeavor, there are many insights we might learn as to the creation of works with cybernetics in mind, or how cybernetics influences modern artistic creation in general. These insights are found in the many processes of creation and fabrication and in the systems enacted through the composition of the work, as well as through human subject feedback in real-world testing environments, which was conducted as a concert experiment (the premiere of the work). Rather than proving that cybernetics is useful, I find through producing CONSTRUCTIONS that cybernetics as a framework was incredibly easy to integrate with my artistic endeavors, as it seems already engrained in many of the broader trends

of modern experimental composition: action and control, systems of conduct/semiotics, generative[20] elements, interfacing as a practice, etc.

Overall, I am acutely aware of the trials of asserting a unified realist-constructivist theory of cybernetics; this falls outside of the scope of this paper for several of the reasons outlined above. In light of this, I do not propose any such solutions but instead offer further avenues of research in both realist and constructivist modes of thought as they regard art and artmaking; while this paper does its best to steer clear of any realist approaches and methodologies, it does acknowledge their contributions to the field and offer a few possible research paths for this subject along realist lines of thought. That said, this paper identifies several opportunities for further research in the field in both constructivist and realist frameworks.

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[20] In the sense that a work make incorporate kernel elements of music (a motif, a note, a phrase) and expect or instruct the performer to unpack that information and play based off that information; for example, cell-based musical works, like Terry Riley's *In C*, ask the performer to play a phrase repeatedly before moving to another cell. In this way, the performer is being asked to generate an extended set of pitch material from a small exemplar cell. These generative elements of modern composition are inherently recursive.

Case Studies

In the modern era, techne more or less includes some sort of electronic element. There is no practical way to divorce ourselves – and our artworks – from the mass of networks, devices, clouds, and data streams which form the current mode of technocapital. This is synonymous with the rise of the cybernetic[21] midway through the Twentieth Century. As Kollias correctly identifies in a reading of Truax, "the role of the artist as the creator of all the details of the artistic result has now transformed into that of leading the process of the result's creation." (Kollias 2011)

Figure 7 Schöffer's CYSP 1 in performance. Accessed via https://cyberneticzoo.com/cyberneticanimals/1956-cysp-1-nicolas-schoffer-hungarianfrench/

Case Study I: Schöffer, CYSP 1

For Schöffer, cybernetics was not always a part of his compositional toolbox; his interest for spatiodynamics preceded that. As Guy Habasque describes him in his essay *From Space to*

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[21] This is, of course, not the only major movement that arose globally through the end of the Twentieth Century and, as well, much could be said about the hegemonic rise of neoliberalism, hypercapitalism, and realpolitik which, in conjunction, exacerbated the conditions originally set forth by cyberneticists in the early postwar period.

Time, it was Schöffer's diving into cybernetic theory that imbued his work with a real sense of indeterminism that, to him, resembled human (e)motion. To Habasque, the salient characteristic of CYSP 1 was its cybernetic inherency. "This mechanism, capable of articulated movements and locomotion without the direct help of a human agent, seemed endowed with an almost organic sensitivity. I say 'seemed', for it is quite obvious that no sculpture can be compared to a living being. Nevertheless, as anyone knows who has studied cybernetics a little, once the machine has been fed 'information', it acquires real autonomy of action."[22] An audience/participant account like this works well as a communication study, as it seems Schöffer's idea translated well across audiences. It wasn't theoretically cybernetic, it was cybernetic as a whole, from conception to delivery.

Philips Technical Guide

The Philips Corporation technical guide *Practical Robot Circuits: Electronic Sensory Organs and Nerve Systems* by A.H. Bruinsma serves as a practical starting point for discussing CYSP 1, as it details its construction and formal content in cybernetic language. Written a time where cybernetics, systems dynamics, and computer engineering were more similar than they were discrete, this technical manual provides a deep insight into early cybernetic thought, and the language of that early output by the likes of Mead, Forrester, and Glanville. In this guide, they

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[22] "Cybernetic Zoo." Https://cyberneticzoo.com. *1956 – CYSP-1 – NICOLAS SCHÖFFER – (HUNGARIAN/FRENCH)*, 2009. https://cyberneticzoo.com/cyberneticanimals/1956-cysp-1-nicolas-schoffer-hungarianfrench/.

describe the homeostat as an "electronic brain". They similarly describe *CYSP 1* in the following way:

> "*CYSP 1 (a name composed of the first letters of cybernetics and spatiodynamic) is the first 'spatiodynamic sculpture' having total autonomy of movement (travel in all directions at two speeds) as well as axial and eccentric rotation (setting in motion of its 16 pivoting polychromed plates).*
> *Nicolas Schöffer has executed this spatial composition in steel and duraluminum, into which an electronic brain, developed by the Philips Company, has been incorporated. The whole is set on a base mounted on four rollers, which contains the mechanism and the electronic brain. The plates are operated by small motors located under their axis. Photoelectric cells and a microphone built into the whole catch all the variations in the fields of color, light intensity and sound intensity.* (Bruinsma 1960)"

As such, this work is not just a spatial composition in that it was constructed in space and evolves throughout space, but it actively: 1. is a part of the space in which it configures and reconfigures, and; 2. listening and reacting to the space and those who inhabit it.

> *"All these changes occasion reactions on the part of the sculpture consisting of combined travel and animation. For example: it is excited by the color blue, which means that it moves forward, retreats or makes a quick turn, and makes its plates turn fast; it becomes calm with red, but at the same time it is excited by silence and calmed by noise. It is also excited in the dark and becomes calm in intense light.* (Ibid.)"*"*

Cyberneticists, even in the early advent of the field, understood the ways in which to integrate robotics, telemetry, and data pipelines into their work and, more importantly, were intimately fascinated with the ways in which those elements played a role in the system they created, envisioned, or described.

> *"CYSP 1 launches upon an adventure unique in the history of art. It participates in artistic life on multiple levels. In an actual spectacle, it dances in ballets with one or several human partners. It takes its place in motion pictures. An abstract film, for instance, is being planned, using all possible visual effects, such as the stroboscopic effect which occurs when its polychrome plates turn at the speed of light vibrations, giving an effect of immaterial colored blends; its shadow projected in movements gives the spectacle a double effect. Its transparency confers upon it multiple partially arrested aspects. It can adapt itself to the theater and participate in exhibitions.*
> *It constitutes a living counterpoint, a new and harmonious contrast with the articulated movements of the undulating bodies of humans by its evolutions and its transparent, orthogonal and metallic structure*. (Cybernetic Zoo 2009)*"*

"Spatiodynamic sculpture, for the first time, makes it possible to replace man with a work of abstract art, acting on its own initiative, which introduces into the show world a new being whose behavior and career are capable of ample developments.(Ibid.)*"* In this case, we see the cybernetic aspect of replacement of the human with a machinic element. Indeed, spatiodynamics as an artform has been at the heart of ample development over the last few decades.

Case Study II: Kac and Nakamura, Essay Concerning Human Understanding

As described earlier, Kac and Nakamura's *Essay Concerning Human Understanding* is an artistic experiment of transduction at a distance. A plant and a bird are coupled through a couple of pieces of technical equipment (plus a cage to keep the bird confined[23] throughout the duration) including speakers, microphones, brainwave sensors and software, intermediary software to turn the brainwaves into MIDI, all telecommunicated through Skype over the internet, across 600 miles. Named after Locke's *An Essay Concerning Human Understanding,* the work illuminates a couple facets of networked (social) communication[24] that apply to cybernetics. Like its eponymous counterpart, it assumes that the bird and the plant are blank slates which, after following a set of initial conditions, begin to exhibit specific behavior enacted on it by the system it inhabits; Locke argues this from a social perspective, Kac and Nakamura take a more abstracted route to express the same ideal.

Figure 8Kac and Nakamura's Essay Concerning Human Understanding, plant view (1994)

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[23] From Kac and Nakamura's work description, the bird was "given a very large and comfortable cylindrical white cage".

[24] This notion is, incidentally, also applicable to third-order cybernetics, where multiple networked subjects who are all dependent are considered as an ordered system.

First, the work asserts that the relationship between the bird and the plant were bi-directional: “by enabling an isolated and caged animal to have a telematic conversation with a member of another species, this installation dramatized the role of communication and telecommunications in human lives. (Kac and Nakamura 1994)” The plant– or rather, the MAX-MSP patch interpreting the plant’s electrical data as MIDI information – responds to the birdsong, and the bird responds in kind. This, in isolation, is a close cybernetic feedback loop.

Figure 9 Kac and Nakamura's Essay Concerning Human Understanding (1994)

Second, the work asserts that operant conditions within the testing environment (gallery and office) changed the outcome, nudging the loop into certain modes of operation. This would include humans, the temperature in either office, weather conditions impacting the bird, plant, or telecommunication between either console, etc. “Humans interacted with the bird and the plant as well. Just by standing next to the plant and the bird, humans immediately altered their behavior. When in close proximity, the interaction was further enhanced by the constantly changing behavior of the bird and the plant, which responded by singing more (bird), activating more sounds (plant), or by remaining quiet. (Kac and Nakamura, 1994) ” This is an example of second-order cybernetics in action: it is a system which not only accepts human input, but observes it (the system is mutable, changed by the operator).

Its use within our research is grand; cybernetic systems are not only a useful compositional tool that have been historically used to great success in techno-social critique, but they are also a part of our everyday life, developed and set in place by early cybernetic engineers at telecommunications companies, dynamics labs, and other post-war scientific institutions.

Case Study III: Olafur Eliasson, assorted works

The works by Olafur Eliasson – spanning the course of several decades of experimentation with light, space, and perception – are an existing, contemporaneous manifestation of second order-cybernetics. Specifically, Eliasson's body of work is largely concerned with subjectification and the manifestation of an immanent subjective experience, mediated through forms of technology to either limit or extend the bounds by which a subject may perceive an image.

Works overview

Eliasson's body of work, comprising a set of dozens if not hundreds of pieces incorporating base materials as agents of perceptive influence: light, mirror reflections, and shadow are used to transform the subject's perspective beyond the seemingly possible. A short set of his body of work serve as an exemplar of the artist's craft, aim, and compatibility with cybernetics. The curated artworks are split into three sets, defined by the materials which Eliasson utilizes in those works to achieve a certain effect: 1) mirrors, 2) monofrequency lamps, specifically low-pressure sodium lamps, and 3) light and shadow.

Mirror pieces

The listening dimension (2017) series and Self-Loop (2015) are a selected assortment of Eliasson's mirror pieces. With these works, the artist seemingly extends the physical boundaries

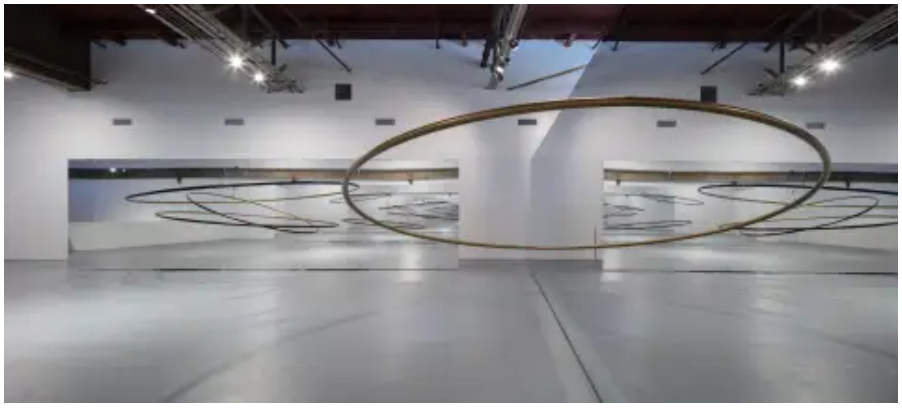

Figure 10 Eliasson's The listening dimension (orbit 1) (2017)

of spacetime with a creative utilization (and illusory placement) of mirrors. The listening dimension is a series of works consisting of large wood pieces in the form of a half torus adjoined to equally-sized mirrors, creating the illusion that the wood pieces extend into the negative space of the mirror, making the half tori look like tori. Self-Loop is a work consisting of several mirrors placed in such a way that the subject can see their side from a vantage point, in order to create the illusion of witnessing oneself in the third person. In either set of works, it is clear that Eliasson is expressly focused on perception and its extrasensory manipulation through what may be considered cybernetic principles.

Figure 11 Eliasson's Self-Loop (2015)

Take Eliasson's work description for the press release announcing the premiere of the work at Tanya Bonakdar Gallery in 2017:

> "*The listening dimension* emerged against the backdrop of the 2016 US elections. At a time when oversimplification is everywhere, I believe that art can play an important role

> in creating aesthetic experiences that are both open and complex. … At its best, art is an exercise in democracy; it trains our critical capacities for perceiving and interpreting the world. Yet art does not tell us what to do or how to feel, but rather empowers us to find out for ourselves. (Tanya Bonakdar Gallery/Eliasson 2017)"

This sort of description, portraying art as the ideal, neutral-democratic utopia, where an input (witnessing an aesthetic experience that is "both open and complex") meets an output (the "find out for ourselves" part of the description) without necessarily needing observance from the system ("art does not tell us what to do") is pure cybernetic thought.

From a cybersemiotics standpoint, this work constructs the conditions of its own observation. We see this similar unpacking of elements by the operant (Subject) that we do with recursive structures. The listening dimension is a work that folds spaces back on itself; this work is not just a work about a torus, but rather the act of seeing, as subjects witnessing the discs construct them in spacetime. Their construction is bound by the act of seeing and only happens at the moment they are witnessed. Inasmuch, this system incorporates both the subject and the space the system inhabits as conditional elements of the work. In a more literal sense borrowing from von Foerster's definition of eigenform[25], the work embodies eigenvalues through its composition: it is not wholly inside reality, but it is coupled through its recursion within the system. Its composition is not material but teleological, arising from the feedback between the physical elements and the viewer (in a position in physical space, think of them as a camera). The tori are given telos through resonance upon the system's modes of convergence. The

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[25] A stable image emerging from circular interaction between physical object and reflected image

listening dimension, like most of Eliasson's works, contains its observer, reaffirming a constructivist mindset.

Let's dissect Self-Loop (2015). In a similar composition to *the listening dimension* (2017), Eliasson continues with the placement of the subject within the system, this time literally triangulating the subject inside the visual feedback loop (as is evident in its title). Through this reflexive, second-order system, the subject's reflection re-enters the optical circuit through successive mirrors ad infinitum; not just a way to see yourself, this work proposes ways to see yourself *seeing yourself.* This collapses the first-order distinction between system and observer; in this configuration, the system is dependent on the subject's position, movement, height, and gaze. Ultimately, it only exists as long as there is someone to watch it; once the subject leaves, averts their gaze, or lose interest, the work as it is currently configured ceases to exist, possibly forever.

As each mirror nests inside the next (at the point of observation, not physically in space, that is), the composition presents an observance of infinite regress, with the subject witnessing a reflection of a reflection of a reflection. In this recursive, iterative configuration, a viewer is able to see themselves from their own vantage point. This state is a state of coherence; the system has been tuned by the subject through their act of observance (and re-observance, and then repositioning, over and over until they stand in the right spot[26]) to achieve stasis. The view

[26] In order to correctly perceive the piece in the correct perspective, the subject must constantly adjust their gaze and position within space; this itself is a cybernetic feedback loop: the subject's corrections work to provide a stabilizing force upon the perceptual output. The work is as such a

stabilizes at the point at which the subject stands in the right place, closing the infinite loop. This in and of itself is an eigenform, a form that arises only through self-referential conditions operating on a system.

Eliasson, as he states in his description for the work, modifies a borrowed concept from East Asian gardening, that of the *borrowed view.* Instead of a distant landscape being presented to the subject, the image is the subject themselves. This is a system which, as Eliasson puts it, "borrows the borrower,"[27] in a recursive set of conditions wherein perception crafts itself. The viewer's embodied perception becomes the site where the system maintains its own composition: it exists only through continuous observation and only for so long as someone witnesses it. Further, each subject is entangled within the system at a different point, such that each perceptive experience is unique. It is not just that once *a person* stops looking at the work that the work ceases to exist for a time being, once *that one subject* moves on, *that set of conditions ceases to converge upon stasis, and the work recurses toward infinity again, untuned;* these set of conditions will never appear again. This speaks more broadly toward the infinite mutability of cybernetic systems.

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reflexive system, one which self-regulates, incorporating error and adjustment as a theory of control.

[27] Eliasson, Olafur. *Self-Loop*. 2015. Wood, mirror, aluminium, stainless steel.

Monofrequency light pieces

In the second category of pieces, the use of monofrequency lamps are Eliasson's simplest method of cybernetic expression. These pieces are central in depicting Eliasson as a cybernetic artist, specifically because of the use of the lamps: in many of his works using such lamps, they are the only medium listed by Studio Eliasson as being part of the artwork. This makes the monofrequency lamp pieces site-specific works which utilize the lamps to exploit their installation site as a mode of transmission. These works show that Eliasson is focused on creating extra-sensory perceptions guided by parascientific manipulation of contemporary technologies, making them key elements of Eliasson's possible oeuvre as a cybernetic artist.

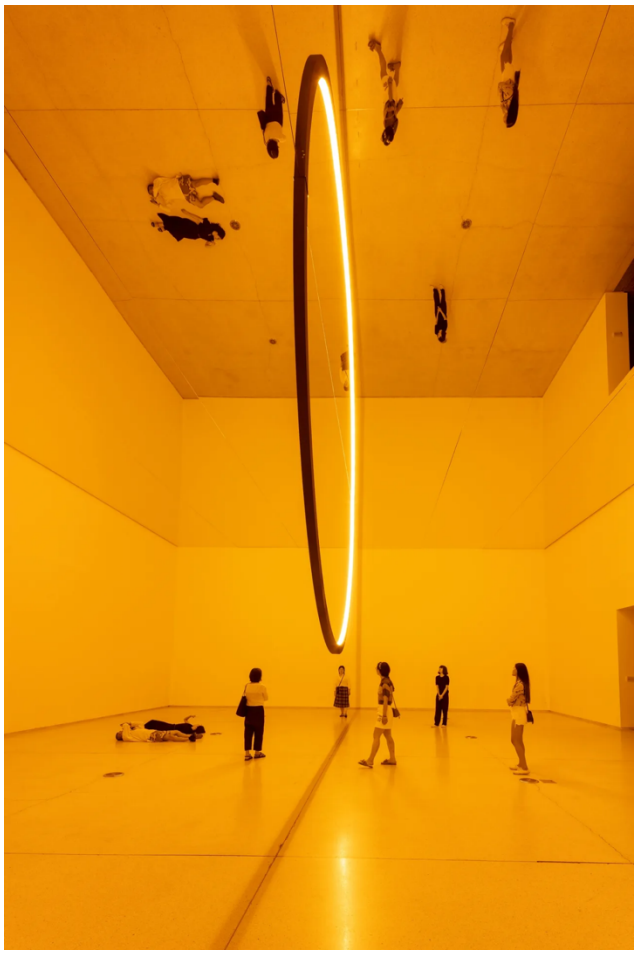

Figure 12 Eliasson's The unspeakable openness of things

The Weather Project, installed at the Tate Modern in the early 2000s, is ostensibly the artist's most recognizable work. From a cybernetic standpoint, his work is a closed system in that it produces its own conditions. 200 monofrequency lights were installed, along with artificial fog and a mirrored ceiling. What appears as "sun" or "weather" is not a representation of nature but a *recursion upon perception itself* – a world brought forth through coupled interaction between

organism and environment. Here we see Eliasson doing what he does best: the work is not the object, but the systems by which the subject and the object are inextricably entangled.

Figure 13 Eliasson's The weather project

The *Weather Project* is Spinozist in that it abolishes transcendence: everything that occurs within it is the expression of a single immanent instance (a sun which doesn't move creates a space which time stays still). Each participant's adaptation to this immanence (squinting, squatting, lying down) enacts a *conatus* – the striving of each node to persist and self-maintain within the systemic totality.

Following Mead and von Glasersfeld, Eliasson constructs a system that models cognition itself, in that:

- it is recursive (the environment perceives itself through human participation, consumption and exhaustion),
- it is constructivist (the reality of the "sun" is maintained only through embodied interpretations), and;
- it is autopoietic (it sustains its own structure by generating the feedback that defines it).

The work's collective participation transforms it into a space of emergent democracy, echoing first- and second-wave cyberneticists' emphasis on *democracy as a cybernetic co-construction* (Curtis 2011).

An additional piece, The unspeakable openness of things, uses the same monofrequency lamp installed inside of ring, amplifying a room with mirrored ceilings. The work was installed at the Red Brick Art Museum a couple years after Room for One Colour and The Weather Project and represents a continuous iteration upon the subject of monochromatic light. The conflux of spatial elements (a mixture of elements from both projects) – a mirrored ceiling, a single monochromatic light in a ring shape, its shadow causing a delimiting band across the entirety of the room – create a dimensional illusion. The ring shape seems doubled in its reflection, causing a horizon to delimit the entire room into areas of "light" (most of the room) and "not a light"[28] where the light itself seems to open up, unfurl past its line of demarcation, spilling onto the rest of the room it occupies.

This system is thus self-referential, involving both the preceptor and the space it in habits. Here, like in other works, perception constructs itself, perception can be seen as a recursive operation that composes itself. The mirrored ceiling aids in this endeavor, folding the act of observation inward (both literally, reflecting more of the photons that hit the ceiling back down onto the ground, and theoretically, giving the light a second half).

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[28] Not "lit" and "unlit", I am speaking specifically on material terms here.

Light and shadow pieces

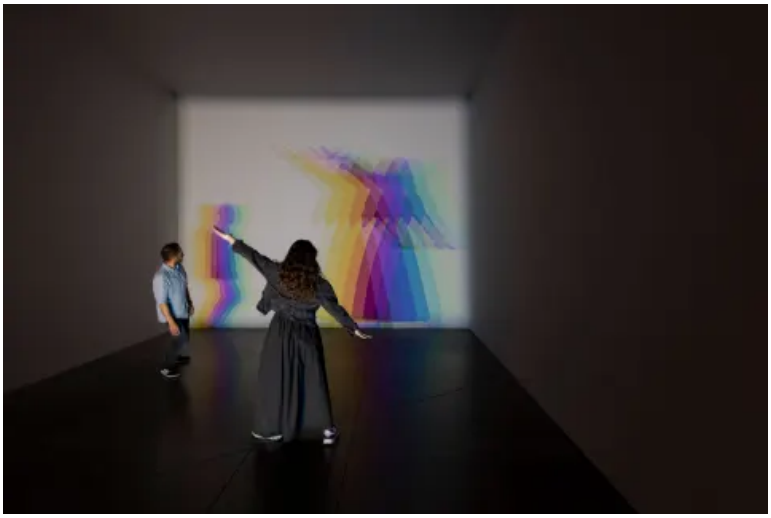

Figure 14 Eliasson's Your own pluralistic coming together

The third set of artworks deal with light and shadow, but in ways that are immediately perceptible and exploitable by the subject, showing a third type of methodologies through which Eliasson practices cybernetic artmaking. These works are constantly in flux, with their system of pulleys, lights, and motors continuously in motion. This alters the play of light and shadow in a continuous arc such that no two moments are alike, eliciting perceptual responses from the subject.

Pluriverse assembly is projection of optical elements in motion. Projected behind a scrim, each moment is a unique constellation of trinkets, providing a momentary configuration of space which pops in and out of existence. In this way, they require observation to facilitate their final, embodying phase in their creation. Eliasson calls these works *radically analogue films*, a beautiful inversion of digital logic. Each optical event depends on the current (observable) state of the system, with no local repetition or predictable outcome. The viewer, in this sense, is not

Figure 15 Pluriverse assembly, by Olafur Eliasson.

merely observing, but granting a life to the artwork. This functions as a stochastic improvisation through non-communicative musical Markov chains.

As no one single element owns the body of the work, no one single element shifts the work in any direction, this work is truly self-organized, arising out of the interplay of the rotating motors, optics, and lighting that creates a meaning of out a set of meaningless initial conditions. This piece continuously reproduces a symbolic order through its componentry in the methods by which those components interact to form emergent visual patterns. Its title is reminiscent of cybernetic writings into a plural reality (reality is what one makes of it, and there are many such realities).

Like Pluriverse assembly, this work uses a series of lights and objects to create emergent films, except where the emergent films in Pluriverse assembly arose from objects in constellation projected behind a scrim, the emergent quality to this work is mediated by the subject and their a.) physical participation in the work, blocking light between a projector and several spotlights, and; b.) perception of their participation, along with their perception of their perception. In a similar fashion to the construction of *Self-Loop*, the subject's presence (position mainly) in Your pluralistic coming together closes the recursive loop that makes the piece undefined – no mirror reflection in one case, all colors summed to white in another. Perception, in this configuration, is an integral part of the composition itself, as the composition unfurls within this plane of existence. Perception informs meaning, conditioning attention, which recursively alters the perceptual field. The white wall and overlapped lights remain static until tuned by the observer.

When an observer moves in front of the spotlights' aim, the system reaches a locally stable mode caused by their disturbance. In this sense, the observant's presence and movement alter the output, which changes how they move in turn, over and over again in a recursive manner.

Figure 16 Eliasson's Your own pluralistic coming together (closeup)

Instead of any pre-written or edited film projected in front of the viewer, the projection serves to enact the film itself live, using the audience as both actor and medium. The image comes from the union of a continuous, self-modulating process and the operators (observers, audience members) who interact with it.

Eliasson makes this system a second-order system in the way that he makes the system observable by the participant. Observation in this case is related to state change; when something is observed, it is changed. By placing the spotlights in such a way where they are both behind the observer and stacked around them, the observer can see themselves as they interact with the system. They can witness their witnessing of the work as they move about the space; through this process, observers become aware of their own observance and control over the system. In cybernetic terms, this work also functions as an ethical model:

- Every shadow depends on others; every action modifies the shared field.
- The piece demonstrates that perception, like society, is plural, co-dependent, and self-organized**.**

- These actions are amplified and converge on a bimodal basis

One of Eliasson's newest outputs, The living lighthouse is recursive even it its construction. A light house, on a material basis, is cylindrical in nature, tower-like for stability and visibility, a beacon in the night guiding seamen to shore. Eliasson's circular installation mirrors the self-reflexivity of cybernetic space itself – an ouroboros, with no beginning or end, only continuous feedback across the space.

Figure 17 Eliasson's The living lighthouse

A lighthouse traditionally sends information outward; Eliasson's lighthouse reverses this logic: it turns the gallery itself into a chamber for feedback, an enclosure where light is treated as

a packet of information which is fed back into the system**.** Light is again a part of the system but, in this configuration, it is that which is being fed back into a specific mode of existence in the work**.** The rotating glass panes act as analog filters – reflecting and diffracting light into shifting chromatic fields, contingent upon where they stand, how long they stay, and the ever-changing angle of refraction (due to the rotation of elements in the center of the "lighthouse").

Studio Olafur Eliasson, by Eliasson's own admission, is a spatial research laboratory first and an arts lab second. At his time at the Studio, Eliasson has enacted a form of techne in designing the materials conditions for self-reference via the extension of perception and creation of cybernetic systems. Even without an explicit declaration from the artist, it can be deduced from their own writing and from the material cybersemiotics of their works the Studio Olafur Eliasson is a cybernetics lab. Following this notion, Eliasson's fascination for extending perception can be read as a fascination for an iterative expansion of the senses, a sort of "order from noise" wherein a system can learn how it sees and how it sees itself. That a system learns to see itself seeing (that a system can organize itself from first- to second-order) is a truly cybernetic viewpoint. Seeing Eliasson's output as such, a system which learns to optimize itself, follows this throughput. The artist's goal in his endeavors is not any sort of representation of the subject, but in the creation of reflexive systems, systems which are able to perceive and perceive themselves; Eliasson leverages those systems to create extra-sensorial perceptions within the Subject's mind, however the artwork is the superposition of the two within the system, not any specific elements within the work.

In closing, Olafur Eliasson's body of work is a recursive practice of practices that forms a self-referential architecture of perception. Ultimately, this assorted collection of artworks bely a pattern of patterns. They are an object unto themselves, a self-referential artwork of artworks –

eigenform – which conforms to second-order cybernetics not just in passing, but as a complete whole. To call Eliasson's body of work an enactment of von Foersters *eigenform* is to claim that his oeuvre is both a record and an operation of recursive cognition, a lifelong, iterative exploration of the fundamental questions of cybernetics: how do we perceive perception? What does it mean to think, especially within the limits of the information presented by our reality? How do the systems at play in our reality shape the way we see it, navigate through it, and interact with it?

Beyond Explicit Cybernetic Art

Now that we have thoroughly established not only the contemporary viability of cybernetics thought-forms as a tool for artmaking, we can begin to apply cybernetic frameworks across a broad spectrum of arts, including works which are not explicitly cybernetic view from such a lens. The question at hand here arises: is there a rigorous second-order cybernetic method to judge these works?

In some way, what we are asking about a work when we judge it through a cybernetic lens is not necessarily *is this work cybernetic;* yes, that might be one's ultimate goal in view a work through cybernetic lenses, but that might yield only a limited number of implicit or explicit cybernetic works. In reality, the most practical criterion by which to judge a work through cybernetics is *can this work be interpreted cybernetically,* i.e. can the work be described through a systems map as a self-regulated loop?

In this case, realist stratagems are quite useful. Masani provides cybernetic methodologies for hard science, and we can take these frameworks and apply them to a subjective context with minimal modification. These cybernetic methodologies save us from the

rabbit hole of knowing and unknowing that is axiomatic cybernetic of cybernetics theory; for example, Masani lays out the following questions

> "Q1: For the scientific enterprise, in which it is postulated that all factual assertions including those of laws of Nature are uncertain (cf. §3(I)), what does authenticity of knowledge mean?
>
> Q2: How is the authenticity of knowledge to be squared with the changing pictures c. of the world that the successive scientific theories present?"

which are proven logically, as a series of operations, rather than axiomatically. The laws of science are uncertain hypothesis, and it is only through the "deductive vehicle" of the hard sciences that turns these hypotheses into testable laws (Masani 1994) He offers that science itself is a recursive practice with an aim toward the best possible truth; this dialectical process occurs iteratively. "The new work thus represents in up-to-date, usable form the wisdom accumulated from the past… This dialectical process is endless. (Ibid.)" To Masani, the answer is a dialectic, Spinozian faith, an asymptotic truth, seeing human knowledge as *sub specie aeternitatis*.

"To those, however, for whom it is an article of faith that the reality is there, this state of non-reconciliation of two seemingly opposed theories of the same entity, is only a challenge to their scientific spirit to probe deeper. To them it is a temporary phase that will pass away. Sooner or later, the opposition will be negated by subsumption in a more authentic theory (cf. §2). But this new theory will give birth to new contradictions. There is no terminus apart from the ideal limit as $T \rightarrow \infty$. (Ibid.)"

Scholte further certifies that these methodologies are transferrable to the artistic plane. This practical example shows it has already been done before, the work here is expansion of domain, not transference. "Maxwell's Black Box… allows us to develop understandings of the

universe without having to claim we know what it's made up of or that we have access to actual mechanisms, emphasizing that our descriptions are descriptions, not to be confused with actuality. (Scholte 2017)" Borrowing directly from SoC doctrine, Scholte describes several artistic settings and scenarios which enact a second-order cybersemiotics. The author is hopeful that the artistic realm remains a fruitful one for cybernetic induction and that there is a reciprocity between the two. "A program of research framing and utilizing naturalist theatre as a second-order cybernetic/cybersemiotic laboratory holds much promise in addressing both matters and lending credence to Ross Ashby's assertion that *'the discovery that two fields are related leads to each branch helping in the development of the other.'* (Scholte 2017)"

He holds that there is a method by which the two opposing cybernetic methods may be satisfied: "an analysis of naturalistic theatre's processes of meaning-making filtered through the constructivist ontological agnosticism of second-order cybernetics offers a productive middle way forward for those on both sides of the social constructivist/embodied cognitive realist divide. (Ibid.)"

Kollias provides this same theoretical lens as to the relationships between art and second-order cybernetics and limits the scope to music (treated as a generative output, i.e. music as a self-organizing system). From the outset, Kollias maintains a radical constructivist point of view regarding SoC: "In second-order cybernetics the observer is also taken into consideration in the modelling process. From this perspective there is no model of reality without its observer. (Kollias 2011) Using his own piece as a framework for "self-organizing music," the author describes several ways in which a musical structure might function in a cybernetic way, through organic and artificial methods of self-organization. From this perspective, musical performance is seen as an in-situ enactment of predefined instructions. "A self-organising work emerges

during a performance from the dialogue between the interpretational model and the occasional context of performance using predefined structures. (Kollias 2011)" Even without explicit feedback-based elements within a musical piece, this process is self-referential; the score unpacks itself, with musicians as the nodes at which the information is processed and read. "The self-organising work of music emerges as a dynamic complex entity. The work is born in the particular context of performance in which it also dies. (Ibid.)"

Where the distinction lies, to Kollias, between cybernetic and non-cybernetic works then is not a black and white discussion – especially now – but a question of gradation, of the amount of control within the system. It is more accurate to talk about degrees of openness of a work in regard to its context of performance. (Ibid.)" "Although the term may be misunderstood to suggest music that magically generates its own existence without the intervention of an external human agent, obviously this is not the case… even if the system is considered as a self-organising one, there is always a level at which control is applied." (Ibid.)

Second Order Cybernetics applied to non-cybernetic artworks

"Even music of fixed medium… has characteristics of open systems. Every time it is diffused, the work's constitution depends on the particular characteristics of the playback system, the acoustic characteristics of space, not to mention the particular social context." (Ibid.) "The sound result is neither determinate nor random and will be different and unpredictable each time." (Ibid.)

Mailman provides useful constructs, axioms by which we may ascribe tangible qualities to creative processes. "The creation of work is the creation of concepts, joining the efforts of theory and praxis in one process (*techné*), such that the results of our works are the expression of an ontological proposition (worldmaking). (Mailman 2016)" So techné is not a *means* toward an

aesthetic end; it *is* the epistemic act itself — creation is in fact an act of the purest ontological inquiry. To create is to live a skilled practice; the practice is the creation itself. This reframes that what Masani calls the *methodological core* of cybernetics (self-reflexive systems) into an aesthetic praxis such that creation and analysis are not considered distinct modes of thinking but a parcel within the greater *techné*. Here, Mailman borrows a definition from Pace: "Pace (2007) contrasts techné with logos, and defines techné as the study of creation of that which could be otherwise (which characterizes the poetic arts) as opposed to that which is necessarily a certain way (the mathematical arts)." (Mailman 2016) This mirrors Masani's assertion of a dialectical, iterative body of science. "Like artistic works themselves, cybernetic phenomenological activities evolve out of past musical and other creative and interpretive practices." (Ibid.)

The Realist-Constructivist divide

It may very well be impossible to unify realist and radical constructivist modes of thought within the cybernetic framework. Indeed, realists and constructivists alike (e.g. Masani) admit that the subfields are opposed. However, if there were a way to unify them, especially within the realm of art and artmaking, the concepts of cybersemiotics, phenomenology, techne, and immanence have a large role to play in that aim. Immanence is the phenomenon by which cybernetics is realized in situ, Kollias and Mailman argue; while neither of them reference the term directly in their output, their writing employs immanentist ontologies: creation, observation, and system are internally co-constituted, leaving no suitable place for a transcendent agent. "Now, with their form-projecting role in view, it's appropriate to consider (synchronic) emergent properties in more depth… like what the philosopher John Locke distinguished as 'secondary qualities…' There is often a sense in music that, as written (or preconceived) notes are animated in sound and in time, a sort of centrifugal force (or momentum) brings forth higher-level

qualities not otherwise present. It is my claim that such higher-level properties … are thus emergent, in some way or another, when taking into account the diverse ways we relate to music, including various modes of listening. (Mailman 2016)" Following this logic, the only system is *the system*, operating at the moment of enactment and ceasing to exist beyond then. This aligns with realist understandings of temporal anisotropy, enforcing a link between the theoretical and the axiomatic (Masani 1994).

It is not my aim to provide an exact basis by which realist and radical constructivist thinking may be standardized or subsumed, but to provide the avenues by which further research may be undertaken to do so. Instead of a theoretical basis of research, I have conducted a practical artistic experiment along the same theoretical lines, expounded upon in the following section.

Practicum: CONSTRUCTIONS, a contemporary cybernetic artwork

CONSTRUCTIONS was conceived from start to finish as a cybernetic work. This means a high interest in recursive models of thought, recursive systems of organization, and interfacing with machines, from planning and fabrication to production and performance. Even from the early planning stages, I identified a couple variables that must be kept:

- Iterative, recursive methods are key
- Consistency in method are key, in spite of (or even because of) the fact that this creation was iterative
- Real systems and dynamics are necessary; nothing metaphorical
- Performers and audience members should interface with the system
- This interfacing should be a part of a greater feedback loop involving the system, of which the subject is an active participant.

- The extent to which this occurs – the extent to which cybernetics transform the work – should be perceptually significant.

Figure 18 The effect of CONSTRUCTIONS' monochromatic light.

In the endeavor of devising a system in which these conditions are met, I worked organically within the bounds set by the material constraints of the mediums I picked: steel, monochromatic light (LPS SOX lights), timber, acrylic, and, perhaps most importantly, electric circuitry. Working these materials provided feedback which, over the course of many months of fabrication, tuned the system in a way; working these materials by hand provided feedback, nudging me to make certain decisions in tooling, processing, composition, and arrangement. As I went along, its final form became more and more apparent, a result of a recursive cybernetic process; one might argue that as I was using this recursive process to present a recursive piece, the output of this work is of the second order of cybernetics.

In its presentable form, it is a series of 6 light sculptures, utilizing three kinds of light: incandescent, through the use of Edison-style bulbs; LED, controlled digitally, at a distance, using the LIFX LED smart lighting application, and; low-pressure sodium light, which is effectively monochromatic light, emanating at around 598.1nm, housed in ballasted lampholders sourced from the City of Palomar. The sculptures fall into two major categories: large works,

made of timber, steel, and other rigid materials, and; small works, constructed with colored frosted plexiglass acrylic. [29]

The three large objects are made to present an impossible depiction of balance (or rather, equilibrium) to the subject. Labeled *CONSTRUCTION A*, *B*, and *C*, each work housed one 135W low-pressure sodium lamp in some way that showed a seemingly impossible scene: a low-pressure sodium streetlight coming out of a patch of grass installed on the stage, a streetlight balanced on the edge of an outstretched C-stand without tipping or falling, a series of blocks both on top and below each other. The small objects (labeled *LIGHT TREE* and *LIGHT SHRUB A* and *B*), each made primarily of acrylic, feature LED and incandescent lights which interact with the colored plexiglass to create visually striking masking and additive color effects as they fire or change colors.

Figure 19 CONSTRUCTIONS as a configurable, connected installation.

As both an homage to Schöffer and a functional component, this work is a spatiodynamic work, using and transforming the space around it in a dynamic, cybernetic manner. It is similarly polystylistic and modular. The large sculptures, *CONSTRUCTIONS A, B,* and *C,* are controlled via smart relays. These smart relays are an extra stage in the electrical circuit chain which enables remote control of the circuit

[29] On light as a purely material object: I chose frosted colored acrylic to condition the light being shined through it without harsh light and shadow.

flow, allowing the user to turn the downstream circuit on or off through Wi-Fi or Bluetooth communication via participating iOS/Android applications like Smart Things (the app we used).

LIGHT SHRUB A and *B* are both cube structures, made of colored sheet plexiglass and welded together, then frosted. Holes were cut out for bulbs, so that they may protrude from the structures, and then jigs were placed to ensure no strain on the cube faces or edge joints. The *LIGHT TREE* was more complicated; it is a 48" monolith (rectangular prism) made of welded sheet acrylic, then laminated with mirror acrylic on each face[30]; on the top of the prism is a tricolor acrylic sheet. Inside the prism is a smart strip LED light, and protruding from the edges are a set of 5 incandescent Edison style bulbs across its four long faces.

These structures are as much a collection as they are a system in motion. Before any discussions of the eponymous symphony associated with the installation, the structures themselves show a precarious motion invoked by their sense of (impossible) balance. Even if one doesn't see them move, they feel the motion expressed in their placement and composition. In terms of performance, these sculptures are also instruments. They are performed in concert in a self-titled symphonic work for 4 switchers and 1 percussion soloist; this symphonic work is scored in (extended) traditional notation and encoded into a scrolling video format, with cues and rehearsal marks embedded into a single DAW instance. Performers, in a green room where they

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[30] Considering mirror acrylic is constructed with a mirror backing that reacts with solvents used in acrylic welding, the form could not be welded together, but attached to an armature or endoskeleton.

can see the lights but not hear switches change polarity[31] follow along on one shared DAW. This DAW instance routes each player's individualized click track to their own loopback channel and displays a video score on a dedicated follow-along track, ensuring sync across the ensemble without any member knowing what each other member is playing precisely. This allows for easy execution of complex phasing and simultaneous improvisation. In this score, performers read ON / OFF states through a two-line musical staff with classical expression text instructions and execute those ON / OFF state changes in rhythm on their mobile devices through smart home applications. Often, one or more members of the ensemble are told to improvise or solo with graphic notation or cells, allowing for the embedding of generative, recursive expression from a performer into the work[32]. The percussion soloist, responding to all of the system as a whole, improvises around each state change. To the audience, the result is that of a random state of variables, until the system snaps into synchrony or otherwise betrays that association.

At a conceptual level, the work undertook an extensive iterative, evolutionary process, ending far away from where the idea originally began; this work was conceived in 2021 as a work for as single staged light sculpture. In its initial stages, the solitary light sculpture had multiple incandescent lights, and would be stochastically triggered by a remote ensemble of

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[31] The smart switches, which I've used in the past for their sonic characteristics, create an audible snap when they turn on or off. These are not precise sonically, multiple switches operating at once create a microtonal cluster.

[32] That is, contemporary experimental improvisational notation embeds a cybernetic oeuvre into a work through the encoding of a small bit of information (cell) that is unraveled by the performer over a larger piece of time than is taken to execute the cell itself.

musicians who both cannot sense the lights nor sense each other's presence (preferably each in a separate room). For a long time, this was my only mental model of the work. This is a far cry from our final idea, but the rational kernel is there; amplified over several revisions and years of thought and general mulling over, the result bears the mark of a recursive process: while some elements tend to extremes (1 minimal sculpture -> very large sculptures, many of them, using heavy materials, concert length), for the most part, a smoothing occurs and rough edges fade (materials testing, post-rehearsal score revisions). Over time, – I wouldn't be able to tell you exactly when, either, it is simply a step along the chain – I began to incorporate the concept of light itself as an instrument; it was a logical extension of the works' already-emergent properties. Further along the line, perhaps facilitated by stimulus from external sources[33], the concept expanded to include multiple sculptures, which facilitated decisions about form, size, construction, etc. Each aspect affected, negated, or reaffirmed other past and future decisions. In this way, thinking in an SoC framework involves thinking superpositionally: there are many feedback loops bound by a single decision tree and, as such, this current, final version of CONSTRUCTIONS is one superposition of a specific mode of conditions which led me to make certain decisions over others. Here, we find ourselves employing recursive frameworks (this recursive thought model) to generate new recursive frameworks (CONSTRUCTIONS). Cybernetics as a system is robust to these kinds of axiomatic constructions.

For the initial performance, the structure took on the following hierarchy: performers reading moving score -> mobile application -> internet service protocol -> smart plug (round trip back to performers, they see this as lag on input status of light switch) -> smart light -> audience.

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[33] Other works, concert experiences, and artmaking, both as a performer and subject.

This system is a closed loop beginning and ending with the performers and working its way through the signal chain and back. In this sense, we see cybernetics in action, as there is recursive interaction, but there is also motion on the system imparted by audience interaction and placement as well. In any case, CONSTRUCTIONS exists not only as an installation, symphony, or performance, but also as an expression of second-cybernetic theory.

CONSTRUCTIONS experienced a second exhibition during CalArts EXPO 2024, the institute's yearly exposition day, with an attendance of around 2,500. This installation-only version featured an audience-tunable system where members could use the LIFX API to instantaneously change the color of any smart light in the collection to see the visual effects of the concurrent monochromatic light on the other light sources.

Case as a cybernetic artwork

In the case of CONSTRUCTIONS as a cybernetic artwork (beyond pure proclamation that it *is* a cybernetic work[34]), there are several factors to consider that may influence one's confidence in the work being cybernetically-derived: a. interfacing with hardware or becoming replaced by hardware; b. systematics which incorporate the observer and the mechanism as part of the system flow (the machine and audience "talk" to each other), and; c. exploitation of self-organization and feedback loops.

Figure 20 View of monochromatic light from afar; here, light takes an architectural form afforded to it by the structures off which it bounces.

[34] i.e. how might we prove the work is cybernetic beyond making the work and saying it is so?

Let's interrogate each claim one at a time, beginning with the idea that *CONSTRUCTIONS* is cybernetic because it is a system which incorporates human interfacing with hardware or human replacement via hardware. This is evident in the performance and instrumental hierarchy embedded[35] in the piece. Performers play instruments – the sculptures themselves – abstracted through a network of relays, switches, and circuits, so that the only contact they have with the instrument is through a device screen (often just one large on/off button), several feet away from the sculptures, which they cannot physically see. In fact, the only feedback they receive from their input is:

- The device screen on/off button (which may be laggy)
- The lights as they turn on and off, a building-length away from them.

This clear both boxes, being both a system by which users can interact with, and on that replaces their positionality with that of a networked system. Performers still perform, but their bodies are replaced by the system. In this way, players also as switchers or phone operators, relaying information, switching states on and off based on a given input, but not necessarily seeing the state switch visually or via confirmation of state change. Performers can be said to be playing the

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[35] I speak about embedding in this context quite often as I want to be clear that I am systematically taking wholesale cybernetic ideas and embedding them as constructs to be unpackaged by performers. I am intentionally taking a programmer's or systems engineer's perspective on the musical composition portion of this work, viewing it as a payload to be unpackaged.

light itself as an instrument, which is a factor afforded by the system's interaction, i.e. this system *allows* you to play light.

This leads us to our second claim, that both performers and audience-members alike can interface with a machinic system, and vice versa (the important part for second-order cybernetics). It is here I am reminded of post-war Nouvelle Vague films like Tati's *Playtime.* Tati, a contemporary of Schöffer, explored new ideas in filmmaking through careful manipulations of mise-en-scene, treating the set as a character itself. One scene in Playtime depicts the film's protagonist – the de facto protagonist, as it seems Tati has less of a fascination with character development as he does set development – walking into a large corporate building for a meeting he has with the director. A porter takes his card and, as he smokes a thin cigarette, sits him down. The porter then begins to relay a message over to someone else – presumably the director's office but we are never fully sure as there is no confirmation – through a massive computer console. This console is a mess of buttons, lights, and switches which confuses even the porter as he tries to report the message of the protagonist's arrival for 90 uninterrupted seconds. As the protagonist waits, we hear the hum of the console in the background for a few minutes as the scene continues. Films like these, especially *Playtime*, were released around the same time where cybernetic thinking was flourishing; the intercom in *Playtime* is a great example of a first-order cybernetic system, where humans are integrated into mechanistic components (but the machine cannot react to them per se, a quality inherent in second-order cybernetics).

CONSTRUCTIONS, at the very least, functions in this way. That is to say, CONSTRUCTIONS clearly fits the model of first-order-cybernetics through this criterion, but what elements of system state-observance (clear markers of second-order thinking) were present,

if any? Could the system flex and react to user input? With *CONSTRUCTIONS*, the system had a significant – albeit limited – bi-directionality. In practice the system worked as follows: performers react to each other, react to latency, react to the score, react to light, but never are hindered by phasing sound. In this way, the system is reflexive, alive, a machine powered by human thinking. Another, more direct way that this system is reflexive in part thanks to its spatial element. Audience ambulatory participation changes the structure in a sense, as – with the Eliasson light pieces – the work is not just the frame (the sculpted elements framing the light) nor the light, but specifically how these elements work together inside a confined space; the lights bounce off walls, floors, and ceilings, no room being alike. As participants walk around, they change the way the light hits the faces of the room, like human density filters. In this more basic sense, the system likewise responds to user input. Taken together, it is not unlikely that human audience interaction could cause changes in light perception by performers, changing the way the lights are operated by the performers, changing the way the audience sees the light, and on and on in a recursive pattern. The frameworks are there for this possibility.

Latency itself plays a vital role in the composition of this piece. Latency is a part of the system which works both upstream and downstream: it changes how audience and the soloist (the people in the room) see the light, when they see it, and how they react to it; however, it also changes which states are accessible to a performer/switcher at any given time. As such, latency is intractable from the work; it forms not only how the light is perceived, but how it is performed and because of that, the system works both ways, as a self-referencing loop. This lands us squarely at our third claim, that CONSTRUCTIONS utilized self-organization and feedback as a major compositional element as an explicit cybernetic oeuvre. There is further evidence of this claim which may help bolster the fact outlined below.

Second-order cybernetics

The subject is part of *CONSTRUCTIONS*, which is inseparable and constantly affecting and affected by the installation. The subject's movements change the light's path; as the artwork unfolds on the surfaces as the light hits them (walls, closed eyelids, etc.), the subject moving about drastically changes the production of light in the space.

Judging the work through second-order cybernetic frameworks would mean different procedures for realist and radical constructivist viewpoints. Let's go through both structures. As stated in the introductory material, while it is feasible to conduct (some kinds of) radical constructivist study into *CONSTRUCTIONS* as a cybernetic work, it is not feasible to do so under realist methods of evaluation.

Building a theoretical framework of the work through logic functions is the optimal place to start. It can easily be done without any specialized testing, through induction and stress-testing of the system in person through fabrication, revision, rehearsal, installation, and performance. This creates a networked map of the system as an "ecosystem", showing its relationships, behavior, and structure; such representation is cybernetic by necessity.

Another possibility for study would be to create human interaction models or psychological studies of the work itself: *how does movement change the work? How does room size change the work? How does a performer's visibility of the system change the work? How does the work change when viewed as an installation rather than performed?* and on and on… These questions are given form through the interaction model. By mapping the modes by which humans interact with the system (instead of just a systems map), this model shows the ways in which the system may be tuned to achieve a certain result.

Subject cognition and personal case studies further assist in tuning the system. By studying how people individually react to the work, via personal feedback or more involved methods (recording brain waves or other neurological research), we can gain insight into the specific modes of interaction that system has. This conforms to current cybernetic research, and building upon this work in this way is in and of itself recursive, self-referential, and using humans to interact with machinelike systems of control. The study itself is cybernetic in nature.

Communication analyses are also helpful in determining the final output as it is understood by the Subject. These analyses functionally determine how ordered the system is, how much entropy is introduced through feedback/human beings (performers and audience members alike). By measuring how able laypeople are at communicating the ideas embedded in the system, we can see how much of the idea is degraded, lost in the system. Measuring up against standardized feedback, entropy, and equilibrium quanta in hard science fields, likely through simulation or stress-testing, would lend realist methodologies to these problems.

Conclusions

In summary, this paper asserts that cybernetics and cybernetic thought, undergirding a large portion of the zeitgeist, has spawned a corpus of implicit and explicit cybernetic art. A radical constructivist approach to art and artmaking offers an insight into the machinations – sometimes quite literally so – at play within the current modes of aesthetic theory. Masani affirms this, by showing us that disciplines and their methodologies evolve together. Art and aesthetic theory can be viewed as participating in an embodiment of this context. As Masani idealizes science as a practice with the expression $T \rightarrow \infty$, so can this idea be applied to the practice of art and artmaking, as a continually evolving practice which is constantly self-

organizing, self-correcting, and self-balancing. In this way, art does not necessarily advance toward clarity as it does converge toward coherence.

Forrester backed this up in his theory of being: Most people think of action as 'here's a problem, I'll take action, and I'll solve it.' Straight line. But that's not the system in which we live. There is a problem, we take action, it may change things, it gives us a new environment for taking the next action and changing things; and so we live in these networks of feedback loops, that are controlling us and those things that we interact with. (Curtis 2011)"

Through historical and theoretical approaches, this paper examined the rise and eventual dominance of first- and second-order cybernetic systems. We explored how first-order cybernetic systems, a system where a user is involved but not observed, arose through the birth of systems thinking and advancement of computer science, through Curtis. Then, we witnessed how the second-order system, the system which observes the user, was introduced and utilized, from art pieces to geopolitical systems of power.

Masani provides an apt warning in recursive practices, that by nature "it can never grasp the whole of its own process. (Masani 1994)" We must realize the limitations surrounding these methodologies. Any sort of empirical validation of claims is by necessity done after the fact; that is to say, any sort of testing of the system requires performance. Inasmuch, cybernetic systems evaluation is ex post facto, while artistic creation largely happens ante facto. [36] With these frameworks, we can judge an artwork's success by how coherent they are to their concept or, rather, how much noise is lost in the systems at play in performance.

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[36] In this way, art and art making are like scientific discovery: abductive, intuitive, heuristic.

This paper posits several implications for the realm of art and aesthetic theory, as well as music pedagogy. Cybernetics forms a large portion of our thoughtspace, and we don't tend to acknowledge it, as it has been subsumed into systems theory, ecology, and other hard science domains. There is a lineage of cybernetic works that explores this output, and acknowledging it, both in the journals and the classrooms opens up recursive methods by which we may advance our craft through its analysis. We've created, now let us analyze.

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