Ecosystemic Thinking: Beyond Human Narcissism in AI

Cesar & Lois, Cesar Baio, and Lucy HG Solomon

Abstract This chapter introduces the reader to critically oriented artworks by Cesar & Lois that propose that AI move away from anthropocentric modes of processing information and toward more ecologically oriented decision-making. The artists argue that the layering of ecological and biological logical inputs within a relational system (ecosystem) has potential as an environmentally aware model for artificial intelligences. They ask: How might an AI reflect the processing and functioning of a healthy ecosystem and support ecosystems? By contextualizing their art that intersects with science and technology, the artists propose the reorientation of machine thinking to living systems, while recognizing the planetary ecosystem as inherently intelligent. By framing microbiological systems as intelligent networks and integrating those with AI, they question what an AI built on knowledge that predates human beings would answer to and the form that its logic would take. This prehuman intelligence has survived and evolved across millions of years, making decentralized decisions across billions of entities as emergent processes. A discussion around nonhuman logic and nonhuman language is linked to the bhiobrid (biodigital) artworks under discussion. By detailing two artworks that propose novel AI's, *Degenerative Cultures* with *Physarum polycephalum* as the model organism and *Mycorrhizal Insurrection*, which integrates the signals of mycelia, the artists' poetic proposition for new networks emerges, along with questions around humanity's relationship to technology, and technology's relationship to the living world. With a look at how anthropocentric orientations of intelligence pervade contemporary art

Cesar & Lois: Independent art collective, US/ Brazil

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and popular culture, the authors question the relationship between the machine and human programmer and the machine's decisions. The chapter considers how human authorship, even in the seemingly neutral area of abstract computations, results in inequities that permeate those algorithms and result in decisions that serve some over others. The artworks that are discussed are proposals for reorienting machines in a way that expands the nonhuman and environmental data entry points of AI training. Their method is to develop intelligences that draw from nonhuman living systems for logical pathways for computing while at the same time critiquing the anthropocentric orientation in the development of sociotechnical systems.

Keywords Creative AI · Practice · Bio-hybridity · Alternative AI · Ecosystems

1 Introduction

This chapter focuses on the artwork of Cesar & Lois, which layers living systems and artificial intelligence to challenge the anthropocentric models that drive decisions in our societies. Our approach to AI, evident in the Cesar & Lois artworks that we discuss in this chapter, is aligned with a critique of the anthropocentric orientation in the development of sociotechnical systems (the systems that society depends on). We understand anthropocentrism to reference the framing of humans as superior rational beings, an idea that sustains Kant's concept of human exceptionalism, established in Kant's distinction of reason as human: "In the lifeless or merely animal nature we see no ground for admitting any faculty, except as sensuously conditioned," while "man" is, at least in part, a "purely intelligible object" (Kant 1922, pp. 442–3). This elevation of human reason persists in technological contexts and is updated in the sociotechnical systems of today. Through our artworks, we challenge this understanding by attempting to think of intelligence through nonhuman parameters. In this text, we point out the anthropocentric ways that technology is conceived and built, and we ask: What if AI functioned without an embedded association with (and preprogrammed elevation of) human thinking?

Cesar & Lois consists of Lucy HG Solomon (California) and Cesar Baio (São Paulo). We are an art collective that works across continents and across species and media, as we experiment with nonhuman logic as the basis for AI. We also attempt to think with nonhuman logic (see Fig. 1).

We grow microorganisms in university laboratories but also in our homes, and these become integrated with the technologies that we develop. For us, thinking creatively about AI means challenging the concept of intelligence as established throughout modernity: one that assumes the (supposed) superiority of human rationality as the sole method of thinking and the default model for the development of technologies. In order to instigate discussions about anthropocentric understandings of intelligence present in those narcissistic models for technology that reflect human thinking, we develop what we call *bhiobrid* (bio-digital hybrid) intelligences, which we materialize in artworks. These artworks allow us to imagine new futures, with

Fig. 1 Cesar & Lois pictured with the logic of *Physarum polycephalum*, or slime mold (Cesar & Lois 2018)

an AI that is ecosystemic and that, by tapping into the decision-making processes that occur in even the simplest life forms, is capable of responding to a network of living beings and to their environments (see Fig. 2 for a model of this layering within an ecosystemic AI). The systems we envision are reflective of a nonhuman logic that takes into account environmental inputs and a complex array of intercellular and intracellular communications that make it possible to understand the planetary ecosystem as an intelligent entity.

In this text, we discuss the development of what could be considered an artistic language that combines both nonhuman and human thinking. This is followed by an interrogation of technological narcissism in (human-reflecting) AI and in a host of popular cultural representations of AI. Microbiological systems as models for computational processing invert the narcissistic tendency of the human intellect and challenges the assumption that an adequate machine is one that successfully impersonates human intelligence (e.g., Turing test). In the artworks that we outline, we propose another kind of AI, one which acknowledges intelligence in microorganisms, whose evolution predates human beings. In our art, we draw on ecosystemic intelligences, which we consider to be a layering of intelligences that draw on an array of logical inputs including simple life forms, networks of living beings, and environments. This layering of AI with nonhuman intelligences challenges the anthropocentric values that drive our society. The proposed bio-digital intelligence is based on and addresses the complexity of enmeshed ecosystems by integrating nonhuman ways of making sense and decisions. This conception runs counter to those concepts of art that place humans at the center in the organization of the world. We as artists contemplate more-than-human networks and imagine the kinds of decisions an AI could make were the AI capable of the complex enmeshed logic prevalent in ecosystems.

Questions about the import of nonhuman languages and the status of the human and the nonhuman in the world drive us to make art that considers nonhuman logic as an input for AI that edits texts about human exceptionalism. Through artworks such as *Degenerative Cultures* and *Mycorrhizal Insurrection*, both based on networking

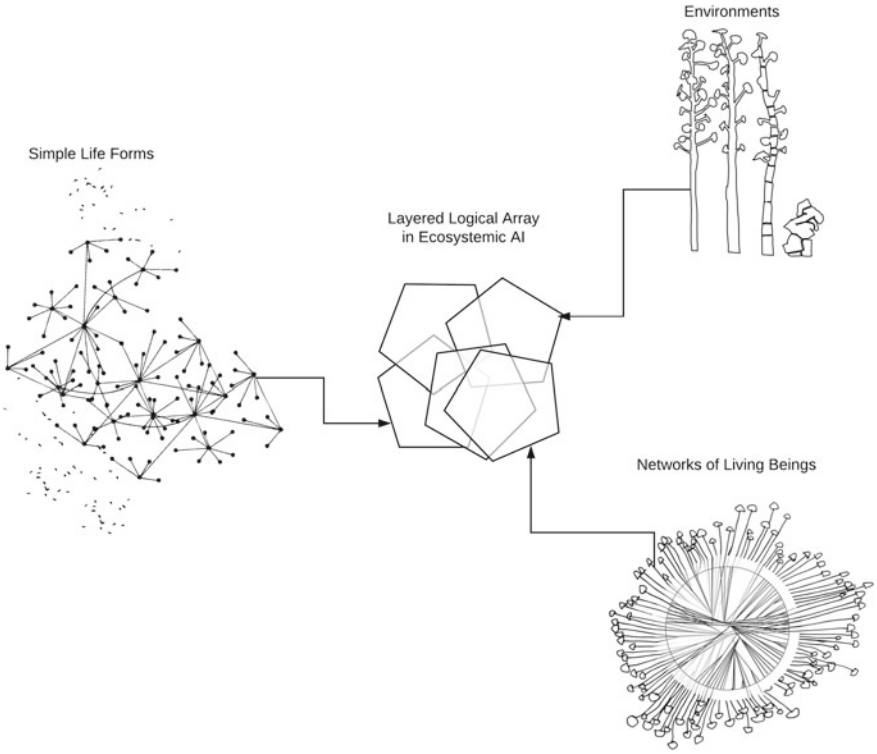

Fig. 2 Diagram reflecting ecosystemic logic as a composite of simple life forms, networked living beings, and environments (Cesar & Lois 2022)

living organisms combined with AI, we examine how nonhuman logic inputs can shift our understanding of language, as well as meaning and context. Our strategies may be considered subversive, as we intervene in and even invent new technologies (for rethinking how to think!). Could a new language result from this hybridization of logics? As part of these conceptual challenges to language, we also examine the concept of AI and question its future, which is symbolically and technologically related to the history of how human beings have framed knowledge, including which models of intelligence prevail in the popular imagination of AI. Our critical approach to human-centered understandings of language, intelligence, and AI is materialized in our artworks, which implies non-anthropocentric AI's that are based on *Physarum polycephalum* (slime mold) and on mushrooms. Throughout this text, we discuss these works and reflect on human and nonhuman decision-making, and we posit a utopian future in which humans and machines think together with other entities. We imagine that the AI and humans of that future could easily balance decisions around life and prosperity with the well-being of the ecosystem and the welfare of other species.

Sequentially, this chapter explores:

- The question of nonhuman logic and nonhuman language.
- A consideration of human-like AI's in popular culture and in art contexts, with examples of artists pushing against the limitations of those.
- An introduction to the artworks, *Degenerative Cultures* and *Mycorrhizal Insurrection*, and their proposals for AI's mapped to nonhuman living systems (slime mold and mushrooms, respectively).
- A proposal for prehuman logic in seemingly simple organisms and embodied intelligence as models for AI, rather than human neurological processing.
- A call for interspecies thinking as a means to formulate ecologically responsive (and environmentally responsible) AI's.

1.1 The Question of a Nonhuman Language

The concept of an artistic language is often discussed in terms relating to the organization of aesthetic elements in certain ways (syntax) which conveys meaning (semantics), and there are many distinctions in how artists and viewers embed intuitive meaning and derive understanding. What is distinct about our approach to the question of language and art is the insertion of nonhuman logic, which does not abide syntax or semantics. We are curious about the way in which this traditional understanding of language becomes problematized by nonhuman logic systems. How might syntax and semantics diverge when driven by mycelia? (see the fungal colonization of a dictionary in Fig. 3) What new meanings and understandings become accessible?

Following thinking around linguistics that breaks from this standard, we consider Nelson Goodman's formative ideas around the capacity of symbols and their systems—inclusive of language, science, art, and other ways of organizing and

Fig. 3 Dictionary colonized with mycelia, an artifact from the series *Thinking like a Mushroom*, with mycelial logic embedded in text (Cesar & Lois 2018)

perceiving reality—to build the world. Goodman acknowledges that the ways that we build that world, whether through the systems of symbols embedded in language, in science or in art (factoring in perception), can limit the very worlds being built: "And even within what we do perceive and remember, we dismiss as illusory or negligible what cannot be fitted into the architecture of the world we are building" (Goodman 1978, p. 15). Can nonhuman sensing (making sense of the world) likewise build a reality? Would this then constitute a nonhuman language? What might a language embedded in an environment, in the land be like, and who or what would speak that language and understand its logic? Could an AI operate based on such a logic, a logic of living beings and environments? In laboratory contexts, in the field, with technological tools and in home growth chambers, we have pondered the logic of various nonhuman entities, including mushrooms (see Fig. 4).

If we picture an ecosystem as a web of relationships that constitutes a "logic" and which underlies a place's inherent language, and then imagine its disruption, then the loss of that ecosystem is also the loss of language. Scientist and author Robin Wall Kimmerer, a member of the Citizen Potawatomi Nation, links being native to a place to speaking its language. Wall Kimmerer describes how her lack of fluency in Bodewadmimwin or Potawatomi (her language had history been different) has left out words, terms, and even concepts from her vernacular.

> My first taste of the missing language was the word *Puhpowee* on my tongue. I stumbled upon it in a book by the Anishinaabe ethnobotanist Keewaydinoquay, in a treatise on the traditional uses of fungi by our people. *Puhpowee*, she explained, translates as "the force which causes mushrooms to push up from the earth overnight." As a biologist, I was stunned

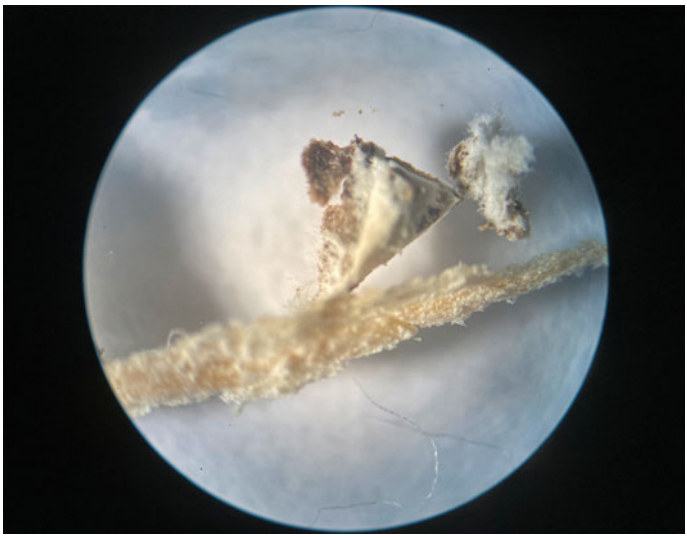

Fig. 4 Microscopy of sectioned fungal specimen with mycelia (a contemplation of nonhuman logic) at Coalesce Center for Biological Arts, University at Buffalo (Cesar & Lois 2021)

> that such a word existed. In all its technical vocabulary, Western science has no such term, no words to hold this mystery (49).

This loss of the language of a place suggests a semantic loss, since the speakers of a place derive meaning from the relationships manifest in that ecosystem. The anthropologist, Eduardo Viveiros de Castro, who examines Amazonian people's relationships to other living beings, discusses whether humans are nonhuman beings and animals are humans:

> If humans regard themselves as humans and are seen as nonhumans, as animals or spirits, by nonhumans, then animals should necessarily see themselves as humans. What perspectivism affirms, when all is said and done, is not so much that animals are at bottom like humans but the idea that as humans, they are at bottom something else—they are, in the end, the "bottom" itself of something, its other side; they are different from themselves. (Viveiros de Castro 2014, p. 69)

Through our work, we speculate about other forms of intelligence that are not human-centered. The anthropologist Eduardo Kohn argues that nonhuman lifeforms can think, and to approach these other intelligences, we must challenge the human models and parameters with which we have historically understood intelligence. Digressing from the strictly symbolic understanding of cognition, Kohn insists: "The first step toward understanding how forests think is to discard our received ideas about what it means to represent something" (Kohn 2013, p. 8). Kohn aggregates theories about representation that extend beyond what humans consider language to argue that nonhuman lifeforms are capable of representing the world.

According to Kohn, the conflating of representation with language happens because we tend to think about how representation works by approaching it in relation to how human language works. Representation in language for Peirce (1991), whom Kohn responds to, is understood through the concept of symbols (an arbitrary sign that is conventional to an object of reference): an abstract assembly of letters is understood to represent something. In Peirce's semiotic theory, other modalities of relationships between signs and the objects of reference are iconic, with signs that share likenesses with the objects they represent, and are indexical, with a cause-effect determination. According to Kohn, lifeforms represent the world in nonsymbolic ways: "These nonsymbolic representational modalities pervade the living world—human and nonhuman—and have underexplored properties that are quite distinct from those that make human language special" (Kohn 2013, p. 8).

Following this argument, Kohn proposes that if we want to understand how nonhuman beings think, we have to change our understanding of representation. Additionally, he advocates for a non-colonial linguistics. Kohn discusses the application of European linguistics to other nuanced cultures—a linguistics that cannot take into account the specific realities and the wealth of worlds created by non-European languages. We would argue that this is also true of attempts to understand the logic of microbiology and even that of artificial intelligences, from a human perspective. "Human" in many theoretical applications represents lineages of colonization that discount the underlying realities of the logical networking of living beings.

1.2 Technological Narcissism

> Without realizing it we attribute to nonhumans properties that are our own, and then, to compound this, we narcissistically ask them to provide us with corrective reflections of ourselves. (Kohn 2013, p. 21).

Often popular imagination understands artificial intelligence as extensions of anthropocentric perspectives of technology and the machine. There are numerous examples in cinema and literature that illustrate the anthropomorphizing of technology, with machines that simulate human thinking, appearance and/or feeling, or with narratives that enmesh fear and love. These include Mary Shelley's *Frankenstein*, *Terminator*, Stanley Kubrick's *Hal 9000,* the replicants in *Blade Runner* (in particular, Rachael, the replicant Rick Deckard falls in love with), and *Her*, the movie in which Theodore falls in love with a personalized operating system. In each, the machine is made human.

Although in the context of computational processing, coding is an abstract aspect of artificial intelligence, the concept of AI, even in the realm of technology, often undergoes an anthropocentric approach. From the technical perspective, artificial intelligence is a computational algorithm, and machine learning distills to machine-based statistics. To deal with the highly abstract mathematical concepts that are necessary to understand and to program computers, most computer theorists reference conceptual models that are based in the anthropocentric understanding of intelligence. A super-human brain becomes a metaphor for AI, with *human* as the primary frame of reference. This is the case in many of the fundamental concepts in current AI development. The idea of artificial neural networks, for example, posits rationality and intelligence as synonyms and suggests that intelligence is associated with a neurological system.[1] As argued in the next sections, this restrictive idea of intelligence does not consider the wide range of microorganisms that function without any neurons and whose decisions have allowed them to survive for millions of years. In our artworks, we propose these microbiological networks as alternative models for computing.[2]

This tendency to shape an AI according to a human model is also expressed in the classic Turing test (Turing 1950). When formulating the idea of a machine that would exhibit intelligent behavior, the mathematician Alan Turing proposed a test. To pass Turing's test, a human must be unable to tell whether one is talking to a machine or a person. Interestingly, the test does not seek to verify if the answers that the machine gives are correct, but rather if the machine's answers are convincingly "human". According to Turing, this would be the way for a machine to present intelligence.

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[1] The article, "The Evolution of General Intelligence," counters, to a degree, human exceptionalism that places animal behavior apart from human rationality. However, the article maintains the brain-intelligence link in both humans and nonhumans and correlates greater intelligence with brain size (Burkart et al. 2017).

[2] See Flikkema and Leid's study of swarm intelligence in bacteria as a potential model for digital networks (Flikkema and Leid 2005).

The impulse to project a human figure on machines is explicit when machines are directed to create human-like output.

In the art sphere, this includes machine-generated representations of human figures presented as artworks. This is also the case in many of the digital artworks that imitate human behavior or language. With the increasing use of machine learning in everyday life, more and more art incorporates AI. Among a variety of approaches, some artists use machine learning techniques to create programs that can learn a specific painter's style and apply it to any image. The user can convert a camera's image into a "van Gogh" or an Impressionist painting. The underlying question posed by these initiatives is whether machines can produce art.[3] Though there are birds that make exquisite nests to impress their mates (Endler 2012), and elephants have been taught to paint unique compositions by wielding paint brushes with their trunks,[4] art is a very human concept—perhaps one of the most anthropocentric ones. To ask if machines can produce art is to project this very human concept on an entity that has an existence completely different from that of humans. It means that any plausible answer to this question can only be reached if the machine in question has been trained with human concepts. If this is the case, then the art does not originate in the machine but with the human who designed the patterns used to train and program the machine. Artworks that assert that machines can make "art" are not often intended to raise questions about the ethics of technologies or their impacts in society, but rather suggest a future machine intelligence capable of imitating human creative activities. This is a human obsession and reflects a machine's goal only if the machine's logic mirrors that of humans, constituting a sort of technological narcissism.

In a strict sense, technology is knowledge applied in the service of doing/solving something. Both the concept of knowledge and the problem to be solved can only exist in a context, which means that technologies are historically situated and responsive to political, economic and ideological interests, and values.[5]In a society that is still driven by notions of development grounded in extractivism and exploitation of both human and nonhuman labor, technology is also a generator of power that privileges a restricted group of people. Artificial intelligence can generate inequities, favor specific groups and outcomes,[6] and these patterns are not always easy to map. Applications and platforms owned by the giant companies that control this industry are part of more and more aspects of our lives, directing our decisions about which routes we take, our relationships, financial transactions and elections; technology informs the ways we represent, understand, and interact with the world. This technological context demands that artists interrogate the relationship between automation and creation, expanding on the art from the last century that reflected contemporary

[3] Note that this question is different from asking if it is possible to produce art with/against/for machines.

[4] It is important to note that elephants do not paint without human intervention. Animal rights activists point to the cruelty of humans making an elephant paint and question the methods and motives of this practice (Barry 2016).

[5] This ties into Vilém Flusser's connection between tools and societal values (Flusser 1999).

[6] See Ruha Benjamin's discussion of racial bias in algorithms in healthcare contexts (Benjamin 2019).

societies' increasing reliance on machines by introducing automation in creativity decades before the information age.

As a result of this updated context, with increasing societal dependence on machine learning running parallel to societal inequities, artists have created manifestos and artworks that challenge the current direction of AI. Caroline Sinders, with *Feminist Data Set*, interrogates AI's biases during development. Sinders writes of the constant process of analysis and questioning: "Every step exists to question and analyze the pipeline of creating using machine learning—is each step feminist, is it intersectional, does each step have bias and how can that bias be removed?" (Sinders 2017–ongoing). The artwork, *Anatomy of an AI*, depicts the societal impacts and environmental and human costs of an Amazon Echo in a detailed information chart (Crawford and Joler 2018). As artists in the contemporary sociotechnical contexts of São Paulo and California and, in a connected sense, the globe, we understand automation, which includes AI technologies, as not only a technical means but as part of a political and economic project. Power as something crystallized in technology. For us, artmaking is a political and poetic act that allows us to critically analyze and develop potential technologies, to challenge the myth of technological objectivity and to conceptually reframe how meaning and power are encoded within these technologies. As discussed in the next section, our propositions are both materially and conceptually represented in our artworks.

2 Artworks as Proposals for Reorienting AI

Cesar & Lois artworks question anthropocentric systems by focusing on the decision-making processes in microorganisms. Creating artworks based on the convergence of bhiobrid intelligences—including processes of prehuman (microorganisms), human, and posthuman (AI) decision-making—is a conceptual and poetic action that proposes a post-anthropocentric conception of intelligence and creativity.

The installation *Degenerative Cultures* (see Fig. 5) creates a bhiobrid network in which living microorganisms and AI work together to challenge the human impulse to control nature, while involving human participants via Twitter. Instead of a human-like AI that can chat or create images within the same logical parameters as that of humans, Cesar & Lois creates a generative algorithm modeled on the microorganism *Physarum polycephalum* and which mirrors the growth logic inherent in this organism. The AI-based digital fungus evolves according to this generative algorithm and corrupts texts on geoengineering found online. This digital degradation results in revisions of the human-centered texts, with the edited versions of the text linked to the logic of microorganisms.

Embedded in the artistic language of Cesar & Lois is the search for how humans relate to technology and how technology relates to the living world. Just as Duchamp displaces industrial objects from their original context to provoke discussions about the object and the artistic act, we displace technologies, protocols, and concepts to generate discussions around digital and living systems. We use technologies with

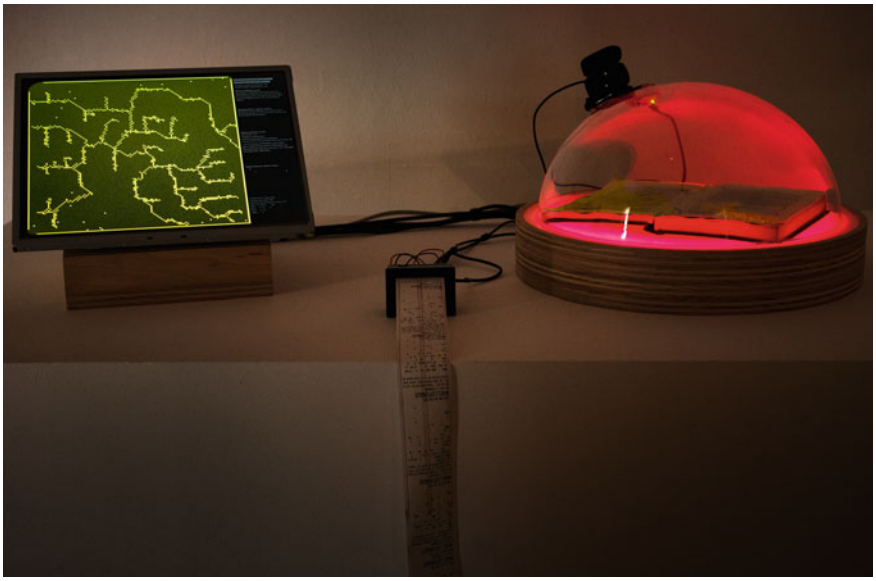

Fig. 5 Installation view of *Degenerative Cultures* at Lumen Prize Exhibition, *Uncommon Natures*, in the Brighton Digital Festival, UK (Cesar & Lois 2018)

different goals from those for which they were created, but also, we modify the conceptual frameworks that drive how we understand such technologies, and we (intend to) give them new meaning. This artistic procedure happens, for example, when instead of designing an AI that mirrors a human being (a task that, by definition, is doomed to fail), the AI is modeled on nonhuman organisms, which function as interspecies networks and which challenge the anthropocentric concepts of the individual and community. In *Degenerative Cultures*, a physical book, one of the main symbols of both the accumulation of knowledge and the human ability to produce cultural tissue, serves as a substrate for living microorganisms (as pictured in Fig. 6). These microorganisms are connected to a digital system based on an AI (Natural Language Processing) that searches the Internet and replicates the microorganism's physical growth over texts that assert human control over all ecological systems.

Although we inoculate the book with *Physarum polycephalum*, the controlled humidity, color, and warmth makes it possible for other microorganisms already present in the book to flourish. From the viewer's perspective, the bright yellow of *Physarum polycephalum* and the yellow generative animation of the AI generate contrast with the growth chamber's red glow (as seen in Fig. 7). The inherent decision-making process of the microorganism, the living book (with the organism growing across it) and the humidity seen through the dome counter the precise logic of the computer-based algorithms. The artistic action of assembling these produces an aesthetic and experiential outcome. Instead of learning the arguments against modern anthropocentrism, those who see and interact with the artwork are invited to consider

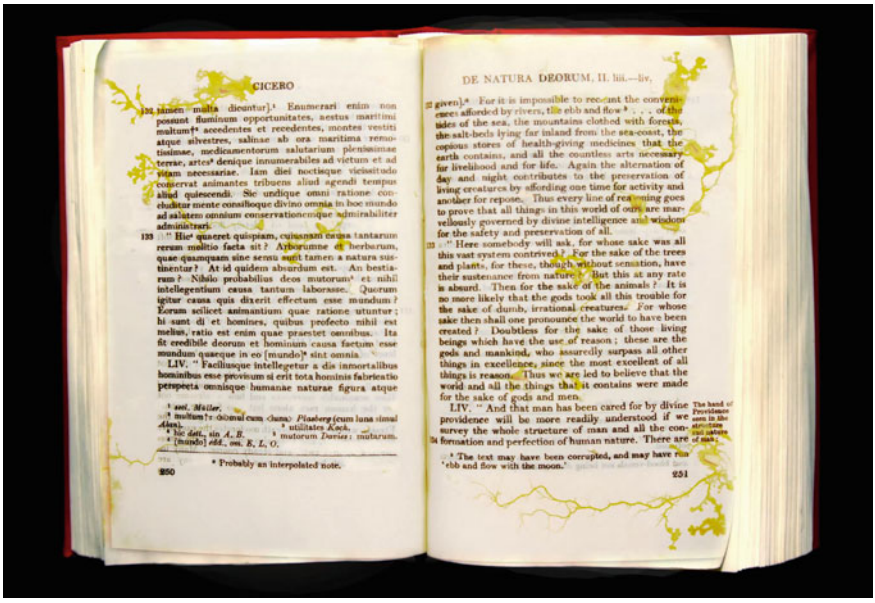

Fig. 6 *Physarum polycephalum* grows over Cicero's text, *De Natura Deorum II*, during growth for the project's iteration for the Aesthetica Art Prize Exhibition, York, UK (Cesar & Lois 2021)

the microorganisms and to contemplate the predatory epistemology of certain human traditions. Within the installation, inserted into the clean biotech aesthetic of the connected growth chamber, is the uncontrollable impulse of life.

In *Mycorrhizal Insurrection*, mushrooms become the conduits for machine processing, with hyphae becoming the conductors of signals for the artwork. The mycelia signals are "electromyceliograms," our word for the mycelial equivalent of electroencephalograms (EEG) (see Fig. 8). In a circular habitat, a floating substrate contains mushroom colonies, whose mycelia send signals to an AI, and viewers can respond by messaging the mushroom colony. A screen visualizes what is happening within the system: the mycelial pulses prompt the AI's metabolic processing of viewers' texts, which become less and less human as the messaging prompts bursts of humidity within the mushrooms' habitat and this in turn affects the electromyceliograms.. User input through social messaging improves the habitat within the cylindrical enclosure, with optimal levels of humidity maintained by these human connections. The mycelial responses to the human input are read as changes in the electromyceliograms (see Fig. 8), which prompt the AI to revise texts with an anthropocentric focus.

This cross-technology or bhiobrid (bio-digital hybrid) system begins with the growth of the mushroom colony, whose mycelial signaling becomes an essential data input for the AI's processing of text. Viewers of the artwork send the system messages and engage with the AI's conversational bot through the exchange of texts, with each message shifting the environmental conditions of the growth chamber

Fig. 7 Viewer peering into the growth chamber of *Degenerative Cultures*, where *Physarum polycephalum* grows across a book by Cicero (Cesar & Lois 2021)

Fig. 8 Reading electromyceliograms, the electronic signaling of mycelia (Cesar & Lois 2022)

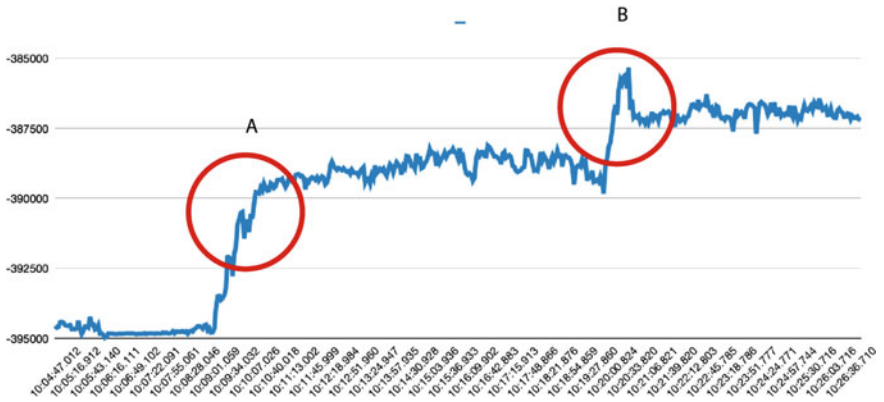

Fig. 9 Graph of electromyceliograms from an experiment with humidity: The first spike **a** happens when a drop of water is added to the fungal colony's substrate; the second spike, **b** demonstrates the change in signaling when water is added to the fruiting body (Cesar & Lois 2022)

and making it more optimal for mushrooms. Correspondingly, the text becomes less and less human. To process the text in this way, the AI learns from a training database and identifies anthropocentric texts, then outputs edited texts in response to the electromyceliograms (see Fig. 9 for a graph of these readings).

This "hyphaened Intelligence," driven by the variations in electric pulses of hyphae, explores nonhuman language by connecting the computer logic of AI and mycelial signaling. The artwork asks how a text might be written for or by nonhumans, or at least revised to reflect nonhuman logic and patterns of being. At the core of *Mycorrhizal Insurrection* is the assertion of a nonhierarchical model of intelligences as conduits for machine thinking, where fungi are valued as sources of knowledge within techno-societal contexts. The artwork is also a launching pad for thinking anew, and with others, about the nature of knowledge. When the connections across living beings become conduits for other logics, new imaginaries emerge.

2.1 Channeling Prehuman Logical Impulses

By making these new logical conduits between prehuman intelligences and artificial intelligence, we propose that thinking across those is possible. In the biological sciences, many researchers have argued that intelligence is not the exclusive privilege of brains. One of the most influential arguments in this direction comes from Francisco Varela and Humberto Maturana, who propose that thinking is embodied, and the nervous system is not the sole information processing system. In Francisco Varela's theory of enactive systems, the world and the cognitive organism determine each other. Dealing with Varela's concepts, Pasquinelli explains that "the organism selects relevant properties of the physical world, and the world selects the structure of

the organism, during its respective co-evolutionary history" (Pasquinelli 2006, p. 34). According to Varela, "…we find ourselves performing that act of reflection out of a given background (in the Heideggerian sense) of biological, social, and cultural beliefs and practices […] our very postulation of such a background is something that *we* are doing: *we* are *here*, living embodied beings, sitting and thinking of this entire scheme, including what we call a background" (Varela et al. 1991/1993, pp. 11–12). From the perspective of embodiment, intelligence emerges in the relationship between a body and the world.

Commenting on R. Brook's discussion of AI, Varela identifies the problem of representation as a problem of understanding cognition without enactment: "The world shows up through the enactment of the perceptuo-motor regularities." Drawing on R. Brook's assertion that the problem with AI (and, Varela adds, with much of cognitive sciences) is the tendency to factor out perception in favor of abstraction, Varela connects intelligent behavior to the situated sensory perception and perception-action that feed cognition. "As I have argued here (and as Brooks argues for his own reasons), such abstraction misses the essence of cognitive intelligence, *which resides only in its embodiment*." (Varela 1992, p. 13).

As artists, we engage in this shift in how we understand intelligence through artworks and, also, in texts where we get inside the theories that support the argument of intelligence in microorganisms (Solomon and Baio 2020). From our perspective, the approach to intelligence as a logical manifestation founded in reason and centralized in the brain reiterates the classical argument of human exceptionalism. This is used to justify the global dominance of capitalist colonialism that, as observed by Moore (2015), is only possible by means of the exploitation of natural forces, including human and nonhuman labor.

The consideration of nature as an external being is less about the essence of the things and more about a projection of power. Simple transactions—filling a gas tank or buying an imported fruit—assert that power and conform to a certain world structure, yet there are societies that affirm relational power structures. Viveiros de Castro articulates the theory of perspectivism, "the ideas in Amazonian cosmologies concerning the way in which humans, animals and spirits see both themselves and one another" (Viveiros de Castro 1998, p. 469). Perspectivism acknowledges that "Western" epistemological debates that center on the dualities of power, ranging from "Nature and Culture" to "body and mind" and "animality and humanity," are ill-equipped to comprehend "non-Western cosmologies" (Viveiros de Castro 1998, pp. 469–470).

On the other hand, many scientific studies have analyzed the cognitive abilities of microorganisms. When discussing some of these studies, Steven Shaviro argues that insects and microorganisms have their own strategy of dealing with their environment and making decisions. Commenting about the abilities of *Physarum polycephalum*, Shaviro writes that the movement of this microorganism "seems not to be centrally coordinated but to involve internal communication among different parts of the organism, that slime molds have succeeded in threading mazes and solving combinatorial problems" (Shaviro 2010).[7]The logic of these decisions reflects a prehuman intelligence and offers possibilities for rethinking the super brain of the

future as a decentralized layering of the logics of multiple organic sources, spanning living entities and ecosystems.

3 Conclusion

In Cesar & Lois artworks, the AI that we develop is not intended to establish an anthropocentric personalized entity that could pass the Turing test, be mistaken as a person, or impersonate human logic. We also don't intend to create a tool that learns aesthetic patterns and replicates those to recreate the work of a human artist. We try to create AI in a non-anthropocentric way. Our way of doing this is by creating bhiobrid systems, in which AI and microorganisms can work together and interact in a way that we humans cannot understand, in a way that does not equate to any human exchange. We strive to better understand these interactions and their nonhuman logic. We ask: If an AI is based on a combination of human and nonhuman inputs, what new pathways are possible to rethink our relations with nonhuman beings, and ultimately change our societies?

When we think about creating an artistic language, we think of the books and organisms that we rely on, each with their distinct ways of interacting with the world. We work with living organisms and with texts that represent human knowledge, and specifically books that represent human-centered thinking. We introduce a living organism to these texts, and this combination of the organism—both how it behaves and its organization—and the text produces an aesthetic that conveys a hybrid AI that moves across both worlds.

Our work makes evident how the AI mimics the behavior of microorganisms. As in the living world where microorganisms and mycelia play a part in the decomposition of organic matter, this AI consumes anthropocentric "ideas," altering texts that assert human dominance over other living entities. We make artworks that are something between living sculptures and digital AI. This in between is what matters to us, because we see the potential of the crossover of the biological and artificial as a possibility for interspecies thinking—thinking capable of responding to an ecosystemic context, not to narcissistic models and human desires.

References

Barry H (2016) Perth Zoo hits out at 'inflammatory and baseless' animal abuse accusations. WAToday.com.au 14 Dec 2016: n. Pag

Benjamin R (2019) Assessing risk, automating racism. Science (Am Assoc Adv Sci) 366(6464):421–422. https://doi.org/10.1126/science.aaz3873

Burkart J, Schubiger M, Van Schaik C (2017) The evolution of general intelligence. Behav Brain Sci 40:E195. https://doi.org/10.1017/S0140525X16000959

Crawford K, Joler V (2018) Data visualization and artwork. Anatomy of an AI system: the Amazon echo as an anatomical map of human labor, data and planetary resources. AI Now Institute and Share Lab. https://anatomyof.ai. Accessed 20 Sept 2020

Endler JA (2012) Bowerbirds, art and aesthetics: are bowerbirds artists and do they have an aesthetic sense? Communicative Integr Biol 5(3):281–283. https://doi.org/10.4161/cib.19481

Flikkema PG, Leid JG (2005) Bacterial communities: a microbiological model for swarm intelligence. In: Proceedings 2005 IEEE swarm intelligence symposium SI, pp 427–430. https://doi.org/10.1109/SIS.2005.1501655

Flusser V (1999) The shape of things: a philosophy of design. (A. Mathews, trans.) (1st English ed.). Reaktion, London

Goodman N (1978) Ways of worldmaking. Harvester Press

HG Solomon L, Baio C (2020) An argument for an ecosystemic AI: articulating connections across prehuman and posthuman intelligences. Int J Commun Well-Being 3(4):559–584

Kant I (1922) Immanuel Kant's critique of pure reason. (F. Max Müller, trans.) (2nd ed.). The Macmillan Company, London

Kohn E (2013) How forests think: toward an anthropology beyond the human. First edição. University of California Press, Berkeley

Moore JW (2015) Capitalism in the web of life: ecology and the accumulation of capital. Verso, London

Pasquinelli E (2006) Varela and embodiment. J Aesthetic Educ 40(1):33–35

Peirce CS (1991) Peirce on signs: writings on semiotic by Charles Sanders Peirce. New edition. Hoopes (ed.). University of North Carolina Press, Chapel Hill

Shaviro S (2010) Fruit flies and slime molds. The Pinocchio Theory

Sinders C (2017–ongoing) Art and technology project. Feminist data set. https://carolinesinders.com/feminist-data-set/. Accessed 30 July 2021

Turing AM (1950) Computing machinery and intelligence. Mind 59:433–460

Varela FJ (1992) Autopoiesis and a biology of intentionality. In: Proceedings of the workshop "Autopoiesis and perception". Dublin City University, Dublin, pp 4–14

Varela FJ, Rosch E, Thompson E (1991/1993) The embodied mind: cognitive science and human experience. Revised ed. edição. MIT Press, Cambridge

Viveiros de Castro E (2014) Cannibal metaphysics. In: Skafish P (ed). Univocal Publishing, Minneapolis

Viveiros de Castro E (1998) Cosmological Deixis and Amerindian perspectivism. J R Anthropol Inst 4(3):469–488. https://doi.org/10.2307/3034157