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Cognition and Intelligence After the Post-Human Turn
Insights from the Brain-Gut Axis

Roberta Raffaetà
Università Ca' Foscari Venezia, Italia

Abstract This article discusses how the post-human turn in science and society is framing cognition, mind and intelligence taking as empirical case the gut-brain axis developed within microbiome science. The article brings into dialogue authors from different disciplines that deal with the relationship between cognition and posthumanism, with the aim to indicate posthumanism's potential but also to warn about the risk of its – more or less conscious – engulfment into a neoliberal framework. Bringing into dialogue an ontoepistemic and a sociopolitical analysis – debates that are too often kept separated – the article indicates that the 'becoming environmental' of cognition, mind and intelligence, far from simply being a dehumanizing gesture that causes anthropocentrism to crumble, is still a very human endeavour, deeply rooted in human history and its varied desires and political aspirations.

Keywords Cybernetics. Microbiome. Gut-brain axis. Computation. Posthumanism.

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1 Introduction

This article discusses how the post-human turn in science and society is framing cognition, mind and intelligence.[1] The aim of the article is not to analyse whether or not cognition is environmental, but rather to delineate the intellectual discourse that is starting to consider cognition as a more-than human issue. Neither does the article advance a normative argument, stating whether this transition is good or bad. My contribution is rather to problematize the issue; this critical cut is embedded in the way different authors have been chosen and juxtaposed. As an anthropologist (with a foundation in philosophy) who studies science and technology and its connection to the environmental crisis, in this article and for the sake of interdisciplinary dialogue, I embrace the idea that anthropology can be, in certain cases, akin to curatorial work (Sansi 2020). I have thus put into dialogue a number of themes and authors from different disciplines, with a bias towards the fields of science and technology studies and socio-cultural anthropology in which I situate myself. What unites the authors mobilized in this article is that they all deal with the relationship between cognition and posthumanism. While other authors in addition to those cited in this article could be recounted, my choice has been functional for my objective to trace a critical genealogy of the current post-human intellectual climate, in which both technoscience and social sciences and humanities participate (Pellizzoni 2015), and the way that it both reverberates into and originates from discourses around cognition and intelligence. This inquiry aims to indicate posthumanism's potential but also to warn about the risks its – more or less conscious – engulfment into a neoliberal framework.

As an anthropologist, I need an empirical locus from which to depart. This is the relatively recent technoscientific revolution in the study of microbes, tiny organisms not visible to the human naked eye, which connect humans with their environment. The current study of microbes relies on computational techniques and is very different from what it used to be a few years ago, when microbes could be seen and studied mostly as a result of laboratory cultivation that allowed the examination of microbes on a plate. A major limit to this technique lay in the fact that approximately 99% of the microbes populating the earth are not cultivatable in the laboratory – the so-called

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1 I use the term 'cognition' as the general framework of the special issue, the term 'intelligence' as linked to the reference, in the article, to computational cognition and artificial intelligence, and 'mind' because, as the article will show, its plays an important role in cybernetics and its popularization.

"great plate anomaly" (Robinson, Bohannan, Young 2010, 455). The need to cultivate a microbe in order to study it has been done away with by metagenomics. This is the study of microbial communities in their natural environment, based on the application of advanced DNA sequencing techniques to a microbial community's members. The results of sequencing are then analysed thanks to various informatics tools, some of which are also implemented with artificial intelligence and machine learning. Metagenomics defines the microbiome, that is, the ecological community of microbes that live in a given environmental sample. The concept of the microbiome is first of all the outcome of a technological revolution, part of a data-driven science that is changing all the sciences (Raffaetà 2022; Kotliar, Grosglik 2023).

Metagenomics has turned away from looking at one individual genome at a time by sequencing genome fragments, using computation to overlap these random segments and reconstituting them into larger continuities. Metagenomics departs profoundly from the methods of isolating individual microbes and culturing them, the mode of knowledge-making that dominated microbiology from the establishment, in the late nineteenth century, of the discipline in Koch's postulates and the very coining of the term 'microbe'. As Stengers observes (2020, 228), "The 'third-millennium microscope' has […] opened a window on a world of living beings that goes beyond this mode of intelligibility structured around the selection of individual genetic lineages". Perceiving the metagenome involves not just the fathoming of many additional kinds of bacteria that could not be cultured with conventional laboratory methods; it additionally brings both previously known and unknown individual entities into the frame of an interacting community. We have entered an era where health and biological functions are no longer the property of an organism but rather an emerging property of a network of connections between the human body and the environment, as well as within the human body, also called the "holobiont" (Formosinho, Bencard, Whiteley 2022). In this ecosystem of connections, microbes act as connectors between different organs and ecosystems.

From this ecological perspective, microbes relate to cognition and intelligence in several aspects. It is broadly recognized that microbes have an impact on the way the brain functions. The so-called gut-brain axis defines a series of studies that have confirmed an association between features of the gut microbiota and mental disorders, neurological diseases (Liang, Wu, Jin 2018) or cognitive impairments such as dementia (Daulatzai 2014) and autism (Pulikkan, Mazumder, Grace 2019). The gut microbiome is also correlated with major mood disorders such as depression, bipolar disorder and schizophrenia (Bioque et al. 2021), as well as cognitive performances such as learning and memory (Gareau 2014) and mental wellbeing in general (Yong 2016). These studies depict a 'second brain' in the gut, that

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is, ecological and distributed, which somehow de-humanizes cognition. The thorny issue, however, is that so far, the correlation identified between the gut microbiome and cognitive functions says little about the mechanisms of their relationship and causative path (Mayer, Nance, Chen 2022). In other words, studies on the gut-brain axis are limited by the classical 'chicken or egg' problem. This, however, does not mitigate the scientific and popular interest and the hopes fuelled by thinking of cognition and mood as governed by our microbial fellows and thus more ecological.

Scientists, moreover, have moved beyond studying how microbes influence human brain, cognitive and emotional functions. Inspired by the symbiotic horizon opened up by the microbiome turn, they are exploring whether and how microbes themselves 'think' too. Microbes do not have brains, but they perceive stimuli, react to them and act accordingly, meaning that they have proto, ecological forms of cognition. In the 1990s, the microbiologist Pete Greenberg coined the term "quorum sensing"; this refers to an intercommunication system used by microbial populations, based on the exchange of biochemical signals between cells, to convey information needed for survival and regulate the genetic expression of various actions such as movement, cell transformations, DNA transfer and acquisition, and symbiotic interaction. The microbiologists with whom I speak in my fieldwork often refer to the way microbes 'think', somehow anthropomorphizing them, even if within an ecological, symbiotic framework.

How microbes 'think' – or how they influence human thinking – can offer glimpses into a mode of existence that displaces western and human ways of understanding and relating to the world. The microbial turn has inspired many leading scholars, from Donna Haraway to Tim Ingold, to think of symbiotic relations, as opposed to competitive relations, as the grounding of ontology and ethics (Hird 2009). Current studies also address how looking at microbes is emblematic of a more symmetrical and respectful relationship with non-humans and the environment (Brives, Rest, Sariola 2021). Yet the microbial turn, like every turn, is riddled with perils as well as promises (Paxson, Helmreich 2014; Lorimer 2020), especially considering that the microbiome is first of all a technological revolution. Before asking how microbes, brains and the environment are linked, it is therefore necessary to inquire into the intellectual genealogy of microbiome research.

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2 Computation and Mind

2.1 Cybernetics and Counterculture

Microbiome science is first of all a computational endeavour that derives from the ashes of the Human Genome Project, a scientific enterprise that in the late 1990s promised to reveal the secrets of life by deciphering all of the genes in the human DNA. Kay (2000), tracing the history of that project, shows that molecular genetics was initially – and up to the 1940s – linked to biochemistry, aimed mainly at identifying the chemical nature of the organisational structure of cells and molecules. From around the 1950s, however, with the emergence of cybernetic communication theories and the advent of the computer, molecular biology became increasingly configured as a derivative of the mathematical theory of information, setting the seal – from the 1980s onwards – on the field's dependence on computers and sequencing technology. During this transition, microbiology also changed, becoming "a communication science, allied to cybernetics, information theory, and computers" (Kay 2000, 463).

Fred Turner, in his book *From Counterculture to Cyberculture* (2010), shows the connections between cybernetics, computer culture and broader transitions in North American society in the second half of the twentieth century. Turner's analysis is helpful for contextualizing the gut/brain axis hypothesis in computation's origin story. He illustrates how the mingling of bios and technology, along with the dawn of an environmental understanding of cognition characteristic of cybernetics, found its roots in the research laboratories of World War II and, later, in the massive military engineering projects of the Cold War. In 1942, the North American mathematician and philosopher Norbert Wiener – alongside his collaborators Julian Bigelow and Arturo Rosenblueth – began to think about how war system theory could be transferred to biology, in the belief that biological, mechanical and information systems could be considered as analogues of one another. This inquiry was not just technical, since information systems were also seen by these scientists as sources of moral good. The significant influence of cybernetics in many fields stemmed from the fact that it originated as an unprecedented mixture of various disciplines. As Turner observes (2010, 25),

> Wiener did not create the discipline of cybernetics out of thin air; rather, he pulled its analytical terms together by bridging multiple, if formerly segregated, scientific communities. Wiener borrowed the word homeostasis from the field of physiology and applied it to social systems; he picked up the word feedback from control engineering; and from the study of human behaviour, he drew the concepts of learning, memory, flexibility, and purpose.

> Wiener could assemble pieces from such diverse sources because he was in steady collaborative contact with representatives from each of these domains at the Rad Lab, in his famous hallway wanderings at MIT, and in his sojourns to the Harvard Medical School.

This creative mixing of disciplines created a system of interlegitimation that not only made it difficult for nonexperts to challenge the cybernetic rhetoric, but also placed into dialogue fields as different as computation, biology and neurology. This all-encompassing/homogenized discourse became easily popularized, well beyond the technical aspect.

Turner shows how the popularization of cybernetics took place in the encounter with the communitarian social vision of the counterculture of the 1960s and 1970s. This is key for the emergence of an environmental discourse about cognition, as counterculture was in some ways different from left-wing movements that aimed for social regeneration through the traditional techniques of agonistic politics such as manifestations, public consultations and strikes. The counterculture youth culture instead turned inward, towards the mind and consciousness, facilitated by a psychedelic mysticism. Marijuana, peyote LSD, rock music, strobe lights, light projectors, stereo speakers and the various delights of a technological consumer culture were ways to reach what was considered to be a genuine state of mind, one reconciled with the cosmic intelligence. The mind and the planet could finally mirror each other through mystical energies; these were considered to be the sources and content of all systems, being biological, social or technological.

The idea of an expanded consciousness and intelligence, however, was not seen as an end in itself – at least in the counterculture leaders' rhetoric. Rather, the mind was seen as the only conceivable means through which to build an alternative, egalitarian society. Counterculturalists were sceptical of traditional political activism; they distrusted politics, which were considered as part of the social and political ills of postwar US society. Hopes for a new world were glimpsed in a less violent, less rational and more psychologically authentic world. For the counterculturalists,

> the key to social change was not politics, but mind. In 1969 Theodore Roszak spoke for many when he argued that the central problem underlying the rationalized bureaucracy of the cold war was not political structure, but the 'myth of objective consciousness'. This state of mind, wrote Roszak, emerged among the experts who dominated rationalized organizations, and it was conducive to alienation, hierarchy, and a mechanistic view of social life. … Against this mode, Roszak and others proposed a return to transcendence and a simultaneous transformation of the individual self and its relations with others. (Turner 2010, 36)

Inspired by cybernetics, these young people saw the individual, and his or her transcendental mind, as a key element within a looping system of feedbacks, interconnected and somehow indistinguishable from society and the cosmos. The mind and consciousness were, therefore, celebrated as a system in their own right. Inspired by anthropologist Gregory Bateson, an active member of the cybernetic movement who considered that no one could live outside the system, counterculturalists concluded that it was also possible to save the system from within one's mind, in a deterritorialized and decentralized way that was however planetary in scope.

Turner observes that finding refuge in the mind, limited by its borders but unlimited in its potentiality, required counterculturalists to adhere to the imagery of the north American frontier, a new and vast space to be explored and colonized anew, from the inside of one's mind. With this frontier imagery, these youths also maintained its conservative gender, class and race system. Most counterculturalists were

> white, and most were under thirty years of age, well-educated, socially privileged, and financially stable… it was far more common for young, white, highly mobile hippies to find their interests in conflict with those of the comparatively impoverished and immobile populations of Hispanics and African Americans among whom they often settled. (Turner 2010, 77)

From the perspective of counterculturalists, class struggles had to be transcended in the name of the possibility of a regenerated humanity.

2.2 Artificial Life and Artificial Intelligence

From the 1980s, counterculturalists increasingly mingled with the computer programmers and techno-hippies of the Bay area. This meant that the counterculture's dreams did not vanish into history; instead, they were transfigured by an imagined community of linked minds into new language and tools, through new forms of computer-mediated and geographically distributed (potentially global in scale) sociability, in which bodies, the local dimension, material things and embodied participation in civic life increasingly lost their significance. Computation's main feature was to turn every procedure into a calculable process; therefore, the human mind and computation were conceptually conceived as united by their working through mathematical signs, indexed as universal.

The supposed universality of computation, mixed with the emerging environmental ethos of the times, informed new experiments in computation and biology. Anthropologist Stefan Helmreich (2000) describes the emergence of Artificial Life (Alife) at the Santa Fe Institute for the Science of Complexity, an institute established in 1984 by a group of Los Alamos scientists, initially funded by Citibank/Citycorp with the aim to understand the world economy as a complex evolving system. Alife scientists created computer simulations as a way to create artificial worlds. In 1990, Tom Ray, one of the central figures in Santa Fe, created 'Tierra', a computer model of evolution, a "primordial information soup … a computational 'ecosystem' in which 'populations' of 'digital organisms' could 'evolve'…" (Helmreich 2000, 3). For Alife scientists, cognition – amplified by technology – could reach new horizons in newly created worlds, a "oneness with the computer, a oneness achieved when they had an immersed yet detached engagement with a simulation" (187).

Helmreich, however, shows that the mental oneness that scientists experienced was anything but transcendental. It was very terrestrial and of a specific kind. It was "infused with 'culture', or better, a particular culture" made up of ideals of liberal individualism, capitalism, competition and, again, the frontier imaginary of cyberspace as the Old West. As "life made by man rather than by nature" (Langton 1989, quoted in Helmreich 2000, 117), a creationist mythology also fuelled their visions, with scientists feeling like god-like, masculine procreators who could create their own worlds in a sort of immaculate – disembodied, rational and technological – conception. Helmreich describes Alife as a masculine experimental theology in which a universal and planetary-wide rationality could save humanity.

If we consider Turner's historical account and Helmreich's interpretation as sound, then military technoscience, neoliberal economic interests and political ambiguity, individualism, machismo and the frontier imaginary appear to be quite a likely origin story for the coupling between the mind, the environment and computers, and therefore also of the gut-brain axis hypothesis. However, in recent years, a number of authors – illustrated in the next section – have identified the capacity of computation to overcome human cognition, not just in quantity (number of cognitive processes performed in a unit of time) but also in quality (their kind). This would translate the values and ethics that embed computation into a completely different realm, a more-than-human plane of existence with unknown potential for emancipation from a too-human ethic.

3 Computers, Cognition and the Environment

To make their algorithms perform better, the Alife scientists nourished them with contingent elements from the outside world: not only laws taken from evolutionary theory (named 'genetic algorithms' and invented in the 1970s by the US computer scientist John Holland) but also their own values and cultural assumptions relating to gender roles, social hierarchies, desires, political visions etc. The so-called 'unconventional', 'natural' and 'non-classical' computing heuristics were developed to improve computer performance by integrating and in some ways mimicking biological processes. These included

> quantum, molecular, neural, cellular, DNA, and membrane computing; collective intelligence; parallel computation; cellular automata; chaos, dynamical evolutionary, and self-assembled systems; relativistic and collision-based computing; swarm intelligence; photonic logic; amorphous computing; physarum machines; and hypercomputers. (Fazi 2018, 147)

According to some philosophers, however, there is no need to outsource inputs from the outside world in such a way because computation already contains variation and contingency in its same computational formalism due to the infinity and incomputability of logico-mathematical entities. According to Beatrice Fazi (2018; 2019), computation possesses a mode of experience, even if it is not limited to the sensible input of an external empirical reality. Fazi's insight is based on Gödel and Turing's demonstration of incompleteness and incomputability. For both Gödel and Turing, the limits of mathematics were proof "that logico-mathematical reasoning cannot be contained within a finite formulation" (Fazi 2019, 117). This, far from being debilitating, marks mathematics as infinite and indeterminate in its potentiality; therefore, it is able to auto-ingress contingency and variation without the need to recur to external inputs. Fazi takes inspiration from Alfred North Whitehead's "radical empiricism" to ground her theory.

Both Gödel and Whitehead spoke of a rational but also intuitive capacity, more innate in some people than in others, to grasp logico-mathematical entities. Skilled mathematicians, indeed, usually have the capacity to 'feel' and 'see' mathematical entities and their relations in space. However, while for Gödel it is "something like a perception" (Fazi 2018, 120) and hence is still an anthropocentric and embodied intuition, for Whitehead this process – which he called "conceptual prehension" – is impersonal. This impersonal and non-human dimension is, for Whitehead, already empirical because mathematical entities are abstract and immanent at the same time. As such, "conceptual prehension" is not a flight of imagination into a metaphysical dimension but instead extends empiricism to encompass the impersonal and purely rational experience of logico-mathematical entities.

For Whitehead, the assumption that there are some concrete entities separate from abstract entities neglects the fact that reality "is always already too real to be separated out into what is purely physical and what is instead mind-dependent, or into an opposition between a perceived and a perceiver. To be not realist enough means to make a separation between an objective and a subjective reality" (Fazi 2018, 169). For example, natural programming includes empirical phenomena (e.g. evolution laws) but takes these laws as a fact of life. This oversimplifies evolution laws, producing the fallacious[2] idea of an analogy between computation and biological laws.

Inspired by the radical empiricism of Whitehead, Fazi affirms that "computational emergence" (Fazi 2018, 162) exists. This refers to the creation of novelty even in the absence of environmental inputs. Computation, for Fazi, should be considered "an empirical phenomenon among empirical phenomena" (163). As she writes:

> computation is never really only a reduction and […] it never really only represents. Because of formal abstraction, computation is a procedure that is already complex – prior to any coupling with art, matter, or life – insofar as it is ingressed by a quantitative infinity that remains unrepresentable. (57)

The issue at stake for Fazi is not whether or not machines can reproduce human thought, but that computation can create a more-than-human novelty (Fazi 2019; see also Majaca, Parisi 2016). Therefore, the environment, the computer and human minds are in some way connected because they all participate in the same ontology in terms of cognition; Fazi terms this "Universal Computation" or "metacomputational view".

A similar, but slightly different, perspective is advanced by philosopher Yuk Hui, who identifies the emergence of novelty in the computational process of "recursivity" and not in the incomputability of logico-mathematical entities. Recursivity remains at the basis of cybernetics, artificial intelligence and machine learning. It is not

> mere mechanical repetition; it is characterized by the looping movement of returning to itself in order to determine itself, while every movement is open to contingency, which in turn determines

2 Whitehead took issue with the "fallacy of misplaced concreteness", which bases much of science on taking abstractions (e.g. the concepts of space and time) as concrete, external and given things.

> its singularity […] Contrary to automation considered as a form of repetition, recursion is an automation that is considered to be a genesis of the algorithm's capacity for self-positing and self-realization. (Hui 2019, 4)

In his book *Recursivity and Contingency*, Hui traces the intellectual genealogy of a "general organology", a term first used by Georges Canguilhem in 1947 – a year before the publication of Wiener's Cybernetics – to rethink the relation between organism and machine. General organology does not simply assume an equivalence between humans and machines but considers the human-machine assemblage as an organic whole. Hui sees in the contemporary technological condition of artificial intelligence the possibility for a new form of philosophizing, referring to Heidegger's assertion that cybernetics is the end of metaphysics because it resolves the antinomies between mechanical laws and freedom, necessity and contingency, identity and movement, mechanism and vitalism. In a general organology for the twenty-first century, Hui sees the possibility to reconcile humans, minds, environments and machines due to the recursive action of artificial intelligence and machine learning.

To complement these views addressing the self-sufficiency of either the logico-mathematical entities or the process of recursivity, I find it appropriate to juxtapose the reflections of Giuseppe Longo, a mathematician and epistemologist, who brings us back from the plane of abstract immanence to the human ground. Longo (2021) has long theorized that the development of mathematics is essentially grounded in the human experience of being in a world in action, in space and in time. Mathematics, for Longo, is a way of knowing that is "built in the world, to organize and understand the world"[3] (Longo 2010, 16) and therefore is rich in intersubjectivity and history. For Longo, mathematical intuition – as evoked by Gödel and Whitehead – is not impersonal but subjective, intersubjective and aimed at coordinating humans in the environment in which they live. Mathematics is

> rich in meaning, of ordering, of writing, of the iterated movement towards the horizon; the sense of the discrete flow of time. Origin of human, and pre-human as regards small numbers (Dehaene 1997), practices of putting together countable quantities. A meaning rooted in ancient gestures and […] in a plurality of practices.[4] (Longo 2010, 30)

3 The English translations are by the Author. "Costruito nel mondo, per organizzare e capire il mondo".

4 "[R]icco di significato, dell'ordinare, dello scrivere, del movimento iterato verso l'orizzonte; il senso del fluire discreto del tempo. Origine delle pratiche umane, e

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Giuseppe and Sara Longo propose that "from Artificial Intelligence to the biology of the program and of genetic information, we must regain the sense of the body, its space and its radical biological materiality"[5] (2022, 2) because mathematics derives from the human capacity and need for movement and orientation. As such, they seem to suggest that the *a priori* of reality cannot be identified solely in the infinity of mathematical entities or the recursivity of computers but also in the "presence of the biological body in an ecosystem, with its links and interactions with everything that is within this ecosystem, starting from the co-construction of its biological 'niche', its own space"[6] (26). If we contextualize this quote in the empirical case from which this article has departed, it implies that the microbial ecosystem, and its connection to cognition, cannot rely on computational representations alone; it is also created by concrete organisms and their relationship within an environment. This grounding should be taken seriously, embracing consequences that go beyond the biological.

Because grounding mathematics and computation in a human and biological realm, it brings back the issue of human ethics and politics. This has been more fully developed by Alessandro Sarti, a mathematician and Longo's collaborator. He speaks of "heterogenesis" or "morphogenesis" to address how biological, material entities generate emergence and novelty (Sarti, Montanari, Galofaro 2015). For Sarti, heterogenesis includes historical and social dimensions; he calls for the need to integrate "every type of informational objectification with vital, affective and social systems"[7] and "immerse them in historicity"[8] (Pelgreffi, Sarti 2018). In his view,

> mathematics is knowledge among knowledge, and it makes sense if it is put in relation with these other knowledges […] Mathematics, which is a beautiful, generous, imaginative science etc… but it must be thought as one among the other languages, among the other five languages, and anthropology among these is one of my favourite languages.[9] (Personal communication)

pre-umane per quanto riguarda i piccoli numeri (Dehaene 1997), del mettere insieme quantità numerabili. Senso radicato in gesti antichissimi e […] in una pluralità di pratiche".

5 "[D]all'Intelligenza Artificiale alla biologia del programma e dell'informazione geenetica, bisogna riconquistare il senso del corpo, del suo spazio e della sua radicale materialità biologica".

6 "[L]a presenza del corpo biologico in un ecosistema, con i suoi legami e le sue intereazioni con tutto ciò che vi è all'interno di questo ecosistema, a partire dalla cocostruzione della sua "nicchia" biologica, del suo spazio proprio".

7 "[O]gni tipo di oggettivazione informazionale con i sistemi vitali, affettivi, sociali".

8 "[I]mmergerli in una storicità".

9 "[L]a matematica è un sapere tra i saperi e ha senso se viene messa in relazione con questi altri saperi. […] La matematica, che è una scienza bellissima generosissima

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Authors such as Matteo Pasquinelli (2023) and Tiziana Terranova (2004) have illustrated the emergence of artificial intelligence and computation as entangled within specific social and political configurations. Fazi, too, in advancing an aesthetic of computation as a provocation against cognitivism, admits that this aesthetic is "a cold world, in which there are no people" and that it will be necessary, in future work, to complement her insights with cultural and sociopolitical ideas. It is in this direction that we are turning now.

4 Stepping Outside of an Ecology of Mind

In the previous three sections I have shown the technosocial forces that, in the West, have inspired scientists and communities to think of cognition as something not exclusively human but instead distributed throughout the environment. I have also discussed how this has inspired two different approaches, as well as their degrees of variation: one is to consider the environment as an empirical resource to be integrated into computation in order to nourish rationality with contingency and variation; the other finds these already situated within rational reasoning and algorithmic functioning. In other words, the first approach proposes stepping outside the human mind and making it environmental; the other is content to stay within human or computer cognition because it is already contingent and universal at the same time. This is certainly a fascinating debate; both displace cognitivism, though with different arguments. However, is there another way to make sense of cognition? If we step outside of the mind as simply an ontoepistemic[10] object and start to consider it as a historical and political object, we may encounter even more compelling issues.

Social theorist and artist Denise Ferreira da Silva has described Western philosophical thought as a rising attempt to externalize the internal human mind into the external reality. This approach grounds a science that relies on the very possibility of engaging exterior things; this is because the possibility of knowing with certainty is achieved by establishing "that the mind has access to, relates to, and is affected by things other than itself, that is, exterior things" (2007, 31). In other words, "without the idea of exterior things, the mind's distinguishing attribute, interiority, cannot be articulated" (44). Yet, according to Ferreira da Silva, this process of externalization obliterates external things at the same time by engulfing them

fantasiosa eccetera… ma deve essere pensata tra gli altri linguaggi, tra gli altri cinque linguaggi, e l'antropologia tra questi è uno dei miei linguaggi preferiti".

10 For an illustration of how the ontological and the epistemic dimensions cannot be considered as separate, see Barad 2007.

in the internal illusion of a universal and abstract mind. This observation has become particularly salient since Ferreira da Silva has included races and human difference in the Western cognitive engulfment of "exteriority", showing that the expanding Western mind engorges not simply nature, but also culture, and also illustrating how this ontoepistemic move is linked to a political one.

Anthropologist Elizabeth Povinelli makes this clear by critically considering the work of Gregory Bateson, an anthropologist who engaged in and inspired cybernetics. In his seminal work, *Steps to an Ecology of Mind* (1972), Bateson intervened in the dialectic between life and computers and showed their continuity across cognition, in a very similar way to that of Canguilhem and his general organology:

> Let us consider for a moment the question of whether a computer thinks. I would state that it does not. What 'thinks' and engages in 'trial and error' is the man [*sic*] plus the computer plus the environment. And the lines between man, computer, and environment are purely artificial, fictitious lines. They are lines across the pathways along which information or difference is transmitted. They are not boundaries of the thinking system. What thinks is the total system which engages in trial and error, which is man plus environment. (Bateson 1972 quoted in Povinelli 2021, 107)

Cognition, for Bateson, was all-encompassing and emplaced, able to disrupt the boundaries between the human, the computer and the environment; this was so very different from the usual understanding of cognition as something merely associated with the brain. Bateson's distributed cognition has inspired a great number of disciplines and intellectuals and has been important in challenging anthropocentrism's certainties.

Povinelli, however, brings our attention to the fact that in Bateson's theory of mind, anthropocentrism was only dismantled at a surface level. In reality, it has remained intact and untouched as a political and epistemological locus. The key innovation that allowed Bateson to link humans and computers through *cogito* was the consideration of thinking as an environmental, distributed process. However, in his formulation, it was not the thinking that was influenced and modified by the environment but vice versa: for Povinelli, the Batesonian mind assimilates difference in order to celebrate itself. While advocating for the continuum of mind-environment-computers, Bateson also "insists that without a human mind, objects like telescopes, windup toys, computer software, rocks, winds, and corpses are without mind" (Povinelli 2021, 110). This leads Povinelli to assert that "Bateson is not merely examining how minds engorge difference in order to expand their territory; he is also excluding entire regions of existence from mental motion" (110). Povinelli sees in Bateson the apex of

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what many consider anthropology's original sin, that of incorporating otherness to serve the West's own interests:

> As he carefully opened his mouth to incorporate the differences of others, he slowly shaped them into a new metapattern of mind. The more he pulled difference into himself, the more he claimed to be able to abduct the larger metapattern of existence, a wondrous kaleidoscope of aesthetic patterning. (109)

According to Povinelli, "Bateson and a host of new ecologists were building a model of a mind that absorbed others in order to expand mind from the human to the biosphere" (108).

This may seem to be a confirmation of Turner and Helmreich's critiques of cybernetics and system biology. However, Povinelli takes Bateson not only as a figure (in the Foucauldian term) of post-war social and scientific movements, but also as a precursor of the ontological turn, new materialism and posthumanism, intellectual strands that pervade contemporary life and social sciences and humanities. In her book *Between Gaia and Ground*, she analyses these approaches, which – despite their differences – exhibit a common thread, that of imagining "a form of political solidarity grounded in the entangled nature of human and more-than-human existence" (2021, 16). The limiting factor of this attempt, according to Povinelli, is that it starts with an ontological rather than a political and historical preoccupation. In the name of battling against the reductionistic view of 'humans' as different and separate from 'nature', this scholarship considers humans and non-humans as entangled by advancing an ontological claim as a necessary first step to clear the ground and only subsequently proceeding towards a political evaluation of the implications of this consideration.

This methodological primacy of ontology *vs* politics, according to Povinelli, is the rhetorical tool through which Western social theory attempts to imagine a new start. The trick is to posit an ecological ontological foundation *vs* a human foundation, a blank slate that promises to cancel the planetary damage that has been provoked by the Western colonial history of dispossession and exploitation. This, for Povinelli, is a move into innocence with the illusion that "by returning to a set of first conditions – to ontology" (2021, 16), it may be possible to solve the environmental and social problems that afflict humanity today. While I was participating in a series of lectures on climate change at Prada Foundation in Venice in October 2023, the curator of the associated exhibit, Dieter Roelstraete, explained his obsession with genealogies and dates as due to an ardent wish to be able to go back, imaginatively, to the very day before the Anthropocene started. This, he said, would offer the opportunity to choose a different path for humanity. Very composedly, Leslie Lokko – curator

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of the 2023 Venice Architecture Biennale – made the observation that, while this may be a nice idea from Roelstraete's perspective, there are people who do not even know their history. This is because some people can no longer claim or remember to have had a history because it has been destroyed, forbidden and cancelled by Western colonization and its many waves. In other words, to solve the oncoming catastrophe for humanity, it is not enough simply to go back in time. Even if we have goodwill and the sins of our ancestors were not our choice, we are condemned to take responsibility for their consequences: to face the present conditions heavy and full of all the injustices and violence of what has been stratified on the planet before us and try to remediate it in the present from our specific positionality.

I find Povinelli's critique a healthy intervention – if radical at times. She urges us to give priority to the violent, not the ontological, history of colonial racism; to clear the ground, because the first condition is a racial and colonial, not an ontological condition. She invites us to think of the treatment of people – of specific people – instead of abstract minds, even if environmentally twisted. She is sceptical of any general theory of human and nonhuman existence that does not start by asking about the colonial and racial condition, or avoids it:

> every theory of existence – whether positing an ontological entanglement of existence or some form of ontological object (hyper-, hypo-, or micro-) – must begin with and have as its ultimate goal the dismantling of this rolling ancestral catastrophe [*of colonialism and social injustice*]. Any discussion that shifts attention from the uneven social and physical terrain of the ongoingness of this catastrophe or begins with a general theory of the human and nonhuman world contributes to the reinforcement of late liberal capitalism's disavowal of its toxic machinery. (2021, X)

In other words, if we adhere to Povinelli's suggestion, the first question to be posed is not whether minds, bodies, environments and machines are interrelated. Surely they are, and there are different ways of conceptualizing these relations. Rather, the issue to be explored is the question of for whom and for what these relations are activated.

Who gains in the 'becoming environmental' of the mind? What are its outcomes in our human world? The 'becoming environmental' of cognition and all the desires, visions and aspirations that accompany it should be analysed not in abstract but as an ontoepistemological turn that takes place away from a social-political structure that enframes it and produces the contours of its capacity to act in the world. Anthropologist Sarah Franklin (1995) has observed that science's focus has shifted in the last century from understanding facts about nature to understanding the 'secret' of life and its building blocks, mainly for biotechnological exploitation. It is out of the

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scope of this article to delve into the political economy of minds and brains becoming environmental or into the industry interests in microbiome research (van Wichelen 2023; Widmer 2021) and microbial cognition that rest on growing bioeconomy interests based on "biovalue" (Waldby 2002) or "biocapital" (Sunder Rajan 2006). This is a very complex issue, as the depiction of scientists as tough capitalists does not do justice to the important role played, for many of them, by genuine scientific interest or progressive political aspirations. Yet the increasing assetization of nature (Beltrame, Hauskeller 2018; Birch, Muniesa 2020; Pinel 2021) and its connection with neoliberal academia and the research-industry nexus is something that should be considered when assessing the 'becoming environmental' of cognition.

5 Conclusion

This article has taken inspiration from the study of the gut-brain axis and the new science of the microbiome to analyse the 'becoming environmental' of cognition, mind and intelligence in contemporary life and social sciences and humanities scholarship. Retracing the technoscientific nature of the microbiome, which connects minds, bodies, environments, microbes and machines through technology and computation, led me to a critical analysis of its legacy, which dates back to postwar cybernetics and its development into system biology and, more recently, artificial intelligence. The article analyses how various authors have positioned themselves in this debate, depicting a spectrum of approaches that has ranges from one pole that considers cognition to be outside minds and computers to another that identifies the source of cognition as inside computation and minds. By juxtaposing critical and analytical approaches, I argue that an ontoepistemic assessment of cognition becoming environmental cannot be disentangled from sociopolitical and historical considerations. An explanation of cognition cannot be given in abstract and universality; it is a specific output of the Western scientific debate and its encounter with the radical other, being human or more-than-human, and of what we decide to do with this alterity. Cognition is thus the outcome of a dialectic between ontoepistemological claims and historical conditions.

The article's aim has been to offer a critical problematization of the 'becoming environmental' of cognition and mind. Here, I use the term 'problematization' following Foucault; it is taken as a methodological category, the goal of which is not to make any claim about what the topic at hand really is or what can really be known about it. To dwell on problematization is not a problem-solving endeavour; rather, it contributes to tracing the conditions of possibility for the present, as well as possible alternatives. Such an analysis needs to be developed in light of the historically constituted, heterogenous and partially overlapping events and fields that have made it possible. Problematizing is a critical, immanent and experimental conduct with no normative aspirations (Koopman 2013). It is an unbounded, never finished, yet generative undertaking. In this article, I have tried to do this by bringing into dialogue an ontoepistemic and a sociopolitical analysis, debates that are too often kept separated.

This allows me, in this last paragraph, to refer back to the title of this special issue: "De-humanizing Cognition, Intelligence, and Agency". With the concept of 'de-humanization', the editors asked authors to reflect on the concepts of cognition, intelligence and agency in their shift in perspective: from almost exclusively human capacities, which eventually extended into the environment by humanizing non-human spaces, to a post-human, post-anthropocentric posture that takes non-humans as the resource and origin for human cognition. In problematizing the mechanic of this inversed movement (from humans to the environment before, from the environment to humans now), defined by the editors as a process of de-humanization of cognition, I conclude by affirming that the 'becoming environmental' of cognition and intelligence, far from being simply a de-humanizing gesture, is still a very human endeavour, deeply rooted in human history and its varied desires and political aspirations.

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