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Assembling the Brain: Disseminated and Confused Cognition at the Threshold of Ecological Relationality

Ensamblando en Cerebro: Cognición Diseminada y Confusa en el Umbral de la Ecología Relacional

Acoblant en Cervell: Cognició Disseminada i Confusa en el Llindar de l'Ecologia Relacional

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Abstract

The perspective of philosophical posthumanism and the new materialist strands allow a rethinking of cognitive processes beyond the locationist standpoint. Locationism, indeed, acknowledges cognition as being singularly localised: now in neurons, now in the brain, now in the body of an organism that holds logo-centred, individuated and autonomous rationalism. Rather, the proposal of an assemblage-brain, and more broadly of an assembled-cognition, leads towards a rethinking of cognitive processes. Cognition becomes an extended and spread conjunction of processes, which can be barely located, whilst being open on an intensive and relational plane. To what extent is it, however, possible to presume such an ecologisation of cognition? What is the threshold of such a process, in regards to relationality itself, and to the alterities that are not necessarily endowed with a nervous system, or – further – non-biological ones?

In this article we advance the proposal to reconsider the embodied mind as being disseminated and confused, by overviewing some of the latest conceptualisations that offer an understanding of cognition as assembled in relations. Our proposal discusses mind processes as incessant and intensive exchanges amongst materialities. From a recursive, closed and neuro-centred event – a local property that is confined in an organ-organism, or concentrically prolonged from it – cognition extends beyond embodiment and the dualism that separates *embodiness* from a presupposed external; it assembles alterities, emerging as a necessarily ecological and plural process that overcomes the individual, and surpasses life as biologically individuated.

Keywords

Cognition; Critical posthumanism; Ecologies; New materialism; Relationality

Resumen

Las perspectivas filosóficas posthumanistas así como las nuevomaterialistas nos permiten repensar los procesos cognitivos más allá de las lógicas localizacionistas. El localizacionismo se aproxima a la cognición como un proceso singularmente localizado: ahora en las neuronas, ahora en el cerebro, ahora en el cuerpo de un organismo que sostiene un racionalismo logocéntrico, individualizado y autónimo. Sin embargo, la propuesta del cerebro-ensamblaje, así como la concepción más amplia de la cognición-ensamblajada, nos incita a repensar más allá los procesos cognitivos. La cognición se convierte en una conjunción de procesos en extensión y proliferación, apenas localizables, mientras devienen en un plano relacional e intensivo. No obstante, ¿hasta qué punto es posible presuponer esta estructura ecológica de la cognición? ¿Cuál es el umbral en tal proceso en aquello que respecta a la relacionalidad como tal, así como a las alteridades no necesariamente dotadas de sistema nervioso, o -más aún- las no biológicas?

En este artículo articulamos una propuesta para repensar la mente encarnada como diseminada y confusa a través de conceptualizaciones novedosas que arrojan luz para entender la cognición como un proceso ensablajado en lo relacional. Nuestra propuesta aborda los procesos mentales como encuentros e intercambios materiales de caracter incesante e intensivo. Desde un lugar recursivo, cerrado y neuro-centrado —como propiedad local que está confinada en un órgano-organismo, o bien que se prolonga concéntricamente desde él— la cognición desborda lo encarnado, así como el dualismo que establece una serpación entre lo *encarnado* y aquello presupuesto como externo. Al

contrario, la cognición ensabljada alteridades, erigiéndose como un proceso plural y en devenir ecológico que traspasa lo individual, asó como lo biológicamente individualizado.

Palabras clave

Cognición; Posthumanismo crítico; Ecologías; Nuevos Materialismos; Relacionalidad

Resum

Les perspectives filosòfiques posthumanistes així com les nuevomaterialistas ens permeten repensar els processos cognitius més enllà de les lògiques localizacionistas. El localizacionismo s'aproxima a la cognició com un procés singularment localitzat: ara en les neurones, ara en el cervell, ara en el cos d'un organisme que sosté un racionalisme logocéntrico, individualitzat i autónimo. No obstant això, la proposta del cervell-acoblament, així com la concepció més àmplia de la cognició-ensamblajada, ens incita a repensar més enllà els processos cognitius. La cognició es converteix en una conjunció de processos en extensió i proliferació, a penes localitzables, mentre esdevenen en un pla relacional i intensiu. No obstant això, fins a quin ùnto és possible pressuposar aquesta estructura ecològica de la cognició? Quin és el llindar en tal procés en allò que respecta a la relacionalidad com a tal, així com a les alteritats no necessàriament dotades de sistema nerviós, o -més encara- les no biològiques?

En aquest article articulem una proposta per a repensar la ment encarnada com disseminada i confusa a través de conceptualitzacions noves que llancen llum per a entendre la cognició com un procés ensablajado en el relacional. La nostra proposta aborda els processos mentals com a trobades i intercanvis materials de caràcter incessant i intensiu. Des d'un lloc recursivo, tancat i neuro-centrat —com a propietat local que està confinada en un òrgan-organisme, o bé que es prolonga concèntricament des d'ell— la cognició desborda l'encarnat, així com el dualisme que estableix una serpación entre l'encarnat i allò pressupost com a extern. Al contrari, la cognició ensabljada alteritats, erigint-se com un procés plural i a esdevenir ecològic que traspassa l'individual, va rostir com el biològicament individualitzat.

Paraules clau

Cognició; Posthumanisme crític; Ecologies; Nous Materialismes; Relacionalitat

> Not every organism is cerebrated, and not all life is organic, but everywhere there are forces that constitute microbrains, or an inorganic life of things.
>
> (Deleuze and Guattari, 1994, p. 213*; transl. adapted from original* 1991, p. 200)

Introduction: Studying in order to replicate, towards the locationist problem

A drone flies over Namibian skies. It collects images of areas that need reforestation. The data that will be extrapolated will be then employed to analyse the actual conditions of the plants living in the area, to identify and compare with the endemic species of the region in question, but also to plan the flying schemes that are useful to maximise the action of reforestation. By obtaining precise GPS coordinates, the drone will be able to fire its exceptional "bio-bullets": seeds whose germination and growth will be subsequently monitored via the algorithm that instructs, governs and leads the entire process (Airseedtech, n.d.; D'Alessandro, 2022). As the company explains in the promotional video, the objective is to plant, during 2023, around hundred thousand trees per day; all to be done thanks to a system that is openly defined as "intelligent" (*Ibid*.).

This first example of *technochory*[1] adds to the growing list of projects and direct applications of machine learning systems that (often inspired by the fight against global warming) increasingly occupy the paper and web pages of leading national and international news. According to Curry Jansen (2022), we are currently reaching the apex of a third cycle of excited promotion of so-called "artificial intelligence", a wave that is marked by the flourishing of scientific and para-scientific texts on the topic, as well as the more structural publication of critical studies on the social and political construction of AI[2].

An always-rising presence of such technologies, and the extraordinary results that have been reached (and that can be reached) via their constant implementation in the everyday life, caused an evident beyond-the-organic shift for concepts such as *cognition*[3] or *intelligent behaviour*. Indeed, until very recent times, these concepts were only attributed to living beings and often just to some species, particularly those species that are provided with a brain, or at least with a nervous system and that, for this reason, have been for a long time considered to be "superior"[4].

The study of intelligence (in particular of human one) and the attempt to formalise and reproduce it – conceptually and performatively – via computational processes has been one of the principles that oriented neurosciences since the half of the last century (Crafword, 2021). As Alan Turing (1950) argued in his pioneering study on intelligence and

[1] Offering an analogy with zoochoric dissemination, which happens via human and non-human animals (zoochory), the term 'technochory' is here coined as a neologism. The term is useful to understand and define the automated and passive dispersion of seeds happening via technologies that are developed by the human animal.

[2] For recent critical studies about the social and cultural construction of machine learning systems see O'Neill (2016); Broussard (2018); and Crawford (2021). For a classic study on the limits of artificial intelligence in philosophical terms see Dreyfus (1972).

[3] Our conceptualisation of cognition derives from the ways in which human thought has been reconceived for instance in Varela, Thompson and Rosch (1991); Clark (1997); Lakoff and Johnson (1999); that is by rethinking cognition as an emergent activity within a complex system; the result of an interaction between the embodied mind and the environment (Gibbs, 2006; Malafouris, 2013). However, the aim of such a contribution is to precisely stress such a conceptualisation beyond the limits that will be later introduced; in particular, the limits of 'externalism' (i.e. Rowlands, 2003). For a concise overview of extended cognition, see Klumbyté (2018); for a more detailed study on the extended mind, see Rupert (2009).

[4] We are not interested here in the historical conceptualisation of intelligence. For a critical account on its understanding before the qualitative shift occurred in the twentieth century see Daston (1997).

computation, starting from the assumption about the existence of different intelligences, the possibility of a thinking machine can be developed by aligning it with the cognitive process of a human child in a learning developmental stage: providing such a technology with the tools that are necessary to "imitate" an intellective modality of acquisition of information (which can move computational cognitive capabilities closer to more strictly biological ones) is thus plausible.

This conception signs a movement "towards", an imitation, since the true challenge still is the effective possibility to replicate or transfer specific capabilities and complex behaviours from a given somatic reality – a definite material source – to a similar body – an analogous entity that is physically different[5]. For this reason, the research and investigation of replicative models – the examination of the expansion of artificial cognition via the extrapolation, archiving and computation of huge amount of data, and the study of human brain – is aligned with research on the cognitive processes of non-human animals, plants and even bacteria[6].

A second example can be found amongst heterospecifics. In the last decades, cephalopods obtained great scientific attention. Members of the molluscan class, indeed, these marine animals (and particularly the octopus) possess – in comparison to other invertebrates – a more developed nervous system that places them closer to small mammals. With "its" almost 500 millions of neurons, which are mostly spread in the 8 tentacles, *Octopus vulgaris* (common octopus) has been studied to understand such an additional modality of distributed intelligence[7]. The presence of specific cells along the molluscan body suggests, in fact, alternative modalities to conceptualise the cognitive activity beyond the needs of a central and superior organ that contains and coordinates it[8].

A final case comes from the vegetable kingdom: a realm that increasingly fascinates and inspires biomimetic research, which approaches plants by looking for strategies and solutions to be applied to problems of coexistence and survival for human society[9]. This is the case of *Opuntia microdasys*, cactus whose capability to hold even the smallest quantities of humidity, thanks to the particular conical shape of its spines, allows it to grow and reproduce in very arid zones such as the Namibian desert. Recently, researchers from Beihang University designed and realised artificial spines made of polyimide and polystyrene in the attempt to imitate its

[5] This is different from the mere planning and realisation of single units of artificial neurons: a fact that has been effective since a few years ago (Abu-Hassan et al., 2019).

[6] See for instance the phenomenon of "quorum sensing": a biochemical "communication" amongst bacteria that leads to a synchronisation of behaviours within a group of bacteria of the same clade (Miller and Bassler, 2001). Such a process can speculatively be thought as a sort of "cognitive redundancy".

[7] As Godfrey-Smith (2018) confirms, the studies about octopuses have been traditionally conducted via cruel experiments based on electric shocks and amputations. On the contrary, in the last decades, the recognition of the cognitive capabilities of this species led to a significant reform, which included octopuses in the European norms that regulate non-human animal treatment in scientific experiments.

[8] In the attempt to explain the mental complexity of cephalopods, "an independent experiment in the evolution of large brains and complex behavior", and the ways in which the nervous system had developed from a double movement (sensory-motor and action-modelling), Godfrey-Smith (2018) overviews many of the results that have been reached by rigorous studies, observations, but also anecdotes on the behaviour of octopuses. Amongst many, an example is the one of Otto the octopus, who was annoyed by the closure of the aquarium that was holding "him" in captivity and sabotaged the electric system of the building with water spurts (The Telegraph, 2008). Such behaviour was also verified in other specimens in different laboratories (reporting of attempts of interaction with custody staff as well), highlighting the ability of octopuses to adapt to peculiar circumstances (in this case captivity ones), as well as to interact and recognise their human wardens. Equally, other behaviours of these non-human animals were observed and connected to complex cognitive activities: play, the ability to manipulate unknown objects after testing their edibility, and to change colours by mimicking the features of at least fifteen different animals.

[9] See for instance Mazzolai, Beccai, and Mattioli (2014); Favemi et al. (2017); Speck et al. (2017); Speck and Speck (2021).

structure, and hypothesised future uses to fight pollution and drought causing the climate crisis (Bai et al., 2015)[10]. In this cactaceae, as it happens for the cephalopod, the cognitive capabilities are distributed along the body, taking the configuration of its branching cladodes, of its stinging and setose glochids, as well as in the eroticism of its yellow flowers and red fruits: modular elements whose functions and structures inspire bio-engineering, primarily focusing on the performative replicability of singular module or function through the reduction of their ecological complexity[11].

These examples confirm some tendencies that informed neuroscientific studies since their dawn. The parallel between computation – as a symbolic process to represent and elaborate data – and cerebral processes have indeed marked this interdisciplinary field of study since the first research on the so-called "artificial intelligence"[12]. As highlighted by William Bechtel et al. (1998), the study of cognition follows two main axes: one that vertically goes towards the brain, and one that horizontally moves towards the environment. The former approach seems to retrace the steps of the tradition, identifying in the cerebral organ and, consequently, in the nervous system the chief place where to study and define cognition. The latter trajectory, which was already anticipated by James Gibson's (1950; 1966; 1979) studies on visual perception, moves towards the external instead: it decentralises the position of the mind as an embodied centre that holds the cognitive process via an ecological viewpoint. Therefore, understanding the intelligence – of an infant, a bacterium, or software – moves from the assumptive attempt to localise and mathematically reproduce cognitive processes, having ethical and political consequences that will not be discussed here, but that necessarily need to be acknowledged as a starting point, given the current techno-automated drift that, pivoting around the automation of decisional processes, increasingly characterises contemporary over-developed societies[13].

The examples of the drone, octopus, and cactus, allow us to put in contact dissimilar *materico* declinations[14]. Such individuations can be approached by considering their cognitive actions, and thus comprehended as different intelligent behaviours. These cognitive acts are processes and capabilities that come out as the result of such conducts: now of the electric circuits of a microprocessor, now of a specific organ or a specific class of animal cells, now of a-neuronal modules, but always within a locationist and internalist perspective. This is

[10] About the specific case of *opuntia microdasys*' spines in connection with water collection see: Azad et al. (2015); Zhu et al. (2016).

[11] Some observations coming from recent fields of studies, such as plant neurophysiology and psychology, openly talk about 'plant intelligence' (Mancuso and Viola, 2016; Castiello, 2019). The debate divides, on the one side, those who dissuade and negate the possibility and/or the usefulness for concepts such as the one of 'cognition' or 'neurobiology' to understand plants, since these are lacking of neural cells (Alpi et al., 2007; Taiz et al., 2019); on the other side, some other positions insist on the presence of similar processes and models but in relation to phytomorphic configurations (Calvo, 2007; Gagliano, 2017; Parise et al. 2020). On the selective emphasis of biomimetics (which often reduces complex realities in a mere functional problem to be structurally solved via the replication of anatomies and the emulation of localised/localisable agencies, and their engineering), see Fayemi et al., 2017; Speck et al., 2017).

[12] For one of the most influential studies that supported the proposal to align the human mind and computational processes, developing the theory of neural networks as well (a theory that nowadays has a great influence on distributed networks of data computation), see Von Neumann (2012).

[13] For recent studies that focus on the ethical and political consequences of data-intensive technologically-driven automation, see Couldy and Meijas (2019); Zuboff (2019); Andrejevic (2020).

[14] We use the adjective 'materico' here and throughout our work by adopting it from the field of art history. In particular, in he field of painting, the term is often used to characterise the thick materiality of layers of colour. Following this line of argument, we employ the term to stress the constituency of different material individuations, and the need for aesthetic-inspired conceptual tools to perceive them. See Micali & Pasqualini (2019) for details; Cohen (2013) for an ecological reflection on the materiality of colour.

a perspective that assumes them as discrete and autonomous properties originating from and bounded in, a body made of semiconductors, covered in suckers, or strewn with spines.

In its different strands, contemporary critical posthumanism focuses on two main issues regarding the neuroscientific approach to cognition. Strictly tied with its philosophical proposal, the attempt to cast light on such issues has primarily been directed to sharply detach from the hyper-humanist and hyper-rationalist speculations of transhumanism. The transhumanist vision is, in fact, rooted in the Cartesian dualism, and has often amplified the dualist separation between the psychic-cognitive reality and the inert, merely-physical and extended reality, pushing towards the conceptualisation of a disembodied mind that, transcending from the material substratum of the body, can be reproduced and re-localised as needed (Kurzwail, 2012). Secondly, in conjunction with this first controversial issue, the critique denied the ways in which cognition has been often used as an anthropocentric, universal concept aimed to hierarchize the existent[15].

The idea to design, build and thus artificially replicate cognition, as well as the hypothesis to transfer thought processes from a body to another one – from biotic to abiotic matter – is therefore postulated from two intuitive but presumed assumptions: 1. Cognition, the mind or intelligence of any 'system' is a property of, or a specific function enabled by, a body – usually of/through its nervous system. Accordingly, it manifests itself as a highly localizable process (in the brain, in the neurons, or through synaptic transmissions). 2. Such processes are often observed as biologically-individuated and closed – autopoietic – exclusively happening within a body via a retroactive tendency aimed to self-maintenance (perception and action that, underlying the cognitive process, would be its derivation and direct result), and only indirectly involving the 'objects' that are considered to be external to that same body. This assumption implies a reception-adaptation of the nervous system in relation to an external environment: an outside that is often assumed as being indiscriminate, a surrounding in which everything that is not strictly an "organism" inevitably falls into, an exterior that becomes a mere source of information ready to be perceived and elaborated.

This contribution aims to critically discuss and advance a step further beyond these "locationist" assumptions. "Locationism" is indeed the perspective that assumes cognition as being singularly localized: now in neurons, now in the brain, now in the body of an organism that possesses logo-centred, individuated and autonomous rationalism. Conversely, the proposal of an assemblage-brain, and more broadly of an assembled-cognition, pushes towards a rethinking of cognitive processes as being extended and spread, hardly localised, and rather opened on an intensive and relational plane. However, to what extent is it possible to presume such an ecologisation of cognition? What is the threshold of such a process, in regards to relationality itself, and to the alterities that are not necessarily endowed with a nervous system, or – further – non-biological ones?

In the central part of this contribution, we will focus on the locationist perspective, before discussing two recent proposals that attempted to overcome locationism by emphasising the intensive processuality of

[15] The opening words of one of the futuristic and oft-referenced writings of Kurzweil (2012) well summarise these two controversial issues, stressing their conjunction: As the most important phenomenon in the universe, intelligence is capable of transcending natural limitations, and of transforming the world in its own image. In human hands, our intelligence has enabled us to overcome the restrictions of our biological heritage and to change ourselves in the process. We are the only species that does this (p. 1).

cognition – its pre-individual dimension – and the ecological relationality that is useful to its understanding. In particular, we will centre our attention to the concept of the assemblage. Coined in the work of Gilles Deleuze and Fèlix Guattari (1983; 1986; 1987), the conceptualisation of the assemblage lays the foundations for the proposals that are useful to rethink cognitive processes from a materialist standpoint, stressing – as mentioned – their un-thought and assembled dimensions. Subsequently, the conclusive section will briefly sketch our proposal of a disseminated and confused mind. This is a proposal that takes into account the material plane in which it is ethically and epistemologically individuated, attempting as well to circumscribe the thresholds into which cognition can be understood and extended. Hence, the adjective "disseminated" signals the shared co-engagement of alterities in the actualisation of cognitive processes, whilst the term "confused" suggests their mingled and indistinguishable arrangement[16].

The un-thought and the assemblage-brain face the challenge of locationism

Despite the efforts of the posthumanist and new materialist perspectives, dualist oppositions – such as the ones between nature and culture, and matter and meaning – are a distance that guides the study and comprehension of the processes of subjective production. The acknowledgment of a self that becomes a subject is indeed caught between a cognitive biological-inspired position and a more socio-cultural one. The former position localises the neuro-somatic process as being biologically natural. The latter one reads the surfacing of subjectivity in the social and cultural constructs that surround the thinking subject. The locationist model moves in between these two broad camps by theorising and accepting the localised character of the cognitive process and/or as being extended towards the external, but always within a concentric diagram that involves already-localised points of departure such as neurons or cultural products. Therefore, locationism sustained and laid the foundations for a "cognitivisation" of mental processes – offering a place, a well-defined room, for a safe scientific exploration of the so-called "cognitive revolution", that is the development of the interdisciplinary studies of what at that time was arising as cognitive science.

Indeed, neuro-scientific studies offer a model for the locationist subjectivity that is strictly connected to the rooted internal-external dualism; a dualism that, thanks to system and complexity theories, seems to have become axiomatic and barely questionable. Even though, as already mentioned, the hyper-humanist leftovers of the *cogito ergo sum* still echo in transhumanist futurologies, the locationist assumption imposed and crossed the interdisciplinary developments of cognitive studies. From behaviourism to the mind-computer parallel and neural network proposals, from the representationalist theory of cognitive schemes to emotional intelligence propositions and the recent attempts to map cerebral activities, the attempt to study cognition derived from the idea of looking for and searching it in specific, localisable points.

To summarise this historical trajectory: behaviourism (which was dominant in the early stages of the studies of cognition) stressed to the extreme the causes and effects that, from the outside, seemed to

[16] As we are going to argue, the conceptualisation of a disseminated and confused cognition highlights the germinative intensity of cognition, the distributive and non-localisable configuration of cognitive processes. Indeed, our proposal recalls the transience, scalarity and relationality of cognition. In particular, we are aware of the often negative connotations that are associated with the adjective 'confused' but are equally confident that such a term is the best to express the scrambled and hybrid promiscuity of cognitive processes, as well as the perceptual condition that might be ethically and epistemologically triggered by such an understanding.

linearly influence the answers of the conscious brain; thus, even if cognition was thought in regards to external impulses, it was theorised within a definite and localised model of behavioural schemes that were internally maintained by external stimuli. The progression of the mind-computer equivalence amplified such a tendency to localise cognition; at first thanks to the parallel between the mind and software and the idea of information processing, and subsequently thanks to the broadening towards the theory of neural networks (which is nowadays employed in machine learning processes of the so-called "artificial intelligence"). Therefore, the computational approach to cognition consolidated locationism, also via the representationalist model (the idea of mental representations, which are often pre-existent within cerebral structures, as matrixes of the logo-centred cognitive process) that firstly dominated and, subsequently, triggered from the sixties the linguistic turn – a turn led by cognitive psychology in the mature stage of the field of study in question.

Moreover, according to Tony Sampson (2017), locationism survived as well – mostly without consequences – the recent neuro-cognitivist perspectives, such as Antonio Damasio's studies on cognitive emotionality (1999; 2003; 2006), or the emphasis on anxiety and fear of Joseph LeDoux's synaptic brain (2002; 2016)[17]. These researches have the great value to understand the way in which cognition must not be considered as a strictly rational, logo-centred and strongly-individuated process (especially in Damasio the proto-subjective aspect is widely discussed). Nevertheless, they do not fully break the locationist tendency to trace specific places (and times) in which cognitive processes – even though emotionally addressed and charged – happen. The locationist perspective persists in the attempt to approach the cognitive-somatic relation (even if perceptive and thus emotional) as a starting point for an internal state of the brain that opens to its "environment", to its "emotional" world: an emotional surrounding that is always external to it.

If the patterns of synaptic connections define the "where" of embodied cognition in LeDoux (2002) and somatic markers automatize decisional processes in Damasio (2006), it is in the system of mirror neurons that locationism finds a further place of investigation. Initially "discovered" in the inferior frontal gyrus and parietal lobe 'of' a macaque monkey, mirror neurons have been studied as a useful system to explain the mechanism of comprehension and simulation of external actions (Stamenov and Gallese, 2002; Ammaniti and Gallese, 2014). Nonetheless, also in this proposal, it is the neural substratum that, endowed with visual and motor proprieties, rises above as the place for the recognition of external agential capabilities, and production of the ethological reaction to them. The mechanism that is interiorised by the system of mirror neurons thus implies a reciprocal recognition and involvement of species-specific alterities (and beyond) in the process of subjective production; but such an involvement happens by repurposing an identitarian mirroring that seems to negate the hybrid contamination with othernesses at the same time of such a recognition – therefore reinforcing the identicality and closed borders of a stable and clearly localizable cognitive self.

Recently, in the attempt to overcome the limits of the locationist perspective on cognition, some scholars advanced the proposal to rethink cognitive processes via a relational lens, taking inspiration from the deleuzo-guattarian machinic ontology, with its anti-reductionist and materialist critique to universality, normativity and rationality of the

[17] For a psychological approach to emotional intelligence see Goleman (1995); for an update of the different perspectives see Debiec et al. (2014).

Western scientific thought (Deleuze and Guattari, 1983; 1987)[18]. In particular, the concept of the assemblage brain (Sampson, 2017) and the proposal of cognitive assemblages or unconscious cognition (Hayles, 2017) were advanced.

Based on a resolute distinction between being and becoming, machinism (Deleuze and Guattari, 1986; 1987) recognises the ways in which subject and object do not exist as pre-given entities whilst mutually arising through material processes of co-emergence. Rather than taking for granted such discretional poles, machinic ontology attempts to challenge such a classic dualism of phenomenological analysis. Subjects and objects are co-constituted by the mutuality of their relations, which are in turn composed by a myriad of partial states in which continual negotiations happen.

Deleuze and Guttari subsequently re-articulated the relational and process-oriented ontology of the machine in the concept of "machinic assemblage" (1975a; 1987) – a conceptualisation that was coined in the attempt to recharge with agential capabilities the different elements of an emergent complex, but also to highlight the immanent and material plane through which it is possible to relate, in the analytical effort, to such specific assemblages. "Assemblage" is indeed the English translation of the French term "*agencement*": noun that carries the idea of an agential capability that is already present and distributed in the relation itself[19]. More in detail, assemblages are conceptualised to emphasise the connection amongst heterogeneous elements, which can momentarily enter in relation to each other, allowing the surfacing of new functions. Assemblages are thus always collective, and – importantly – stress the absence of a precise place in the localisation of such an emergent relation, and the productivity of the same "diagrammatisation" that attempts to define this relational "place". To say it in other words, the analytic process – the humanist scientific attempt to grasp and represent the existent – is part of the co-determination of the material entanglement itself; both move – even by having different speeds – on the same constituent plane: a not-strictly, or better not-yet-strictly, localizable point within the same plane of consistency[20].

Katherine Hayles' (2017) considerations move in a similar direction. Hayles (*Ibid*.) discusses cognition in processual terms, refusing its attribution to specific entities and reading the broad and diversified diffusion of cognition amongst all living organisms, and in many technical systems as well[21]. Extending beyond the biological domain, her proposal of a 'cognitive unconscious' detects the structural and functional debts of consciousness towards the cognitive processes to which we

[18] Deleuze and Guattari's machinism (1983; 1986; 1987) is part of a broader trajectory of philosophical investigation that stresses the relevance of processuality and relationality in the constitution of the existent, and can be mapped via pre-modern and non-western images of thought (as for instance Buddhism), but also in western philosophical projects such as the ones of Baruch Spinoza (1996), Gilbert Simondon (1989; 2017) (which have directly influenced Deleuze and Guattari's work), or Alfred North Whitehead (1978).

[19] According to Phillips (2006), "Agencement designates the priority of neither the state of affairs nor the statement but of their connection, which implies the production of a sense that exceeds them and of which, transformed, they now form parts" (p. 109).

[20] The critique of the separation between an analytic/descriptive plane and one of existence, which is strongly implied in representationalism, is one of the core elements of our proposal but cannot be discussed here in full. This point has been developed in neo-materialist critiques, which are directly or indirectly inspired by Deleuze and Guattari's oeuvre. In particular, our main reference is the work of Karen Barad (2007) on agential realism, in which such a separation is described as being one between 'matter and meaning' and directed towards a critique of the division between epistemology, ontology and ethics.

[21] The already-mentioned work of Deleuze and Guattari (1987), as well as Latour's actor-network theory (2005), and Auletta's (2011) contributions in the field of cognitive biology inspire Hayles' conceptualisation.

do not have directly – in a conscious way – access. Moreover, advancing the comparison – from a structural and functional viewpoint – between life forms and computational media, Hayles (*Ibid*.) deepens the systematicity of those cultural human-technic interactions, which are at the ground of our ecological relationality and that she conceptualises as "cognitive assemblages".

Cognition guarantees special properties to such assemblages, highlighting a contiguity that acts on multiple areas and levels, being still able to mutate and change according to the context[22].

> [H]umans and technical systems in a cognitive assemblage are interconnected, the cognitive decisions of each affect the others, with interactions occurring across the full range of human cognition, including consciousness/unconscious, the cognitive nonconscious, and the sensory/perceptual systems that send signals to the central nervous system. Moreover, human decisions and interpretations interact with the technical systems, sometimes decisively affecting the contexts in which they operate. As a whole, a cognitive assemblage performs the functions identified with cognition in general: flexibly responding to new situations, incorporating this knowledge into adaptive strategies, and evolving through experience to create new strategies and kinds of responses (Hayles, 2017, pp. 118–119).

Hayles' (*Ibid*.) investigation sheds light on the urgency to rethink the roles and manifestations of cognition in the relation between human and non-human actants[23], suggesting – via the conceptualisation of the assemblage – the embodied contiguity, promiscuity and contamination that can be found in every ecological relation between biotic and abiotic matter. On one hand, Hayles (*Ibid*.) elevates cognition as a primary analytic category with the aim to broaden the typical functions of cognitive processes towards unicellular organisms, plants and computational media (as well as to avoid facing concepts such as the ones of thought and intelligence). However, on the other hand, this compensatory distribution still holds the attribution to such functions to the single parts that constitute a specific assemblage. *Embodiedness* – that is the embodied materiality of any element – determines the level, quantity and quality of cognitive processes, repurposing a pattern of conjunction and interconnection in which eco-ontological, relational intensity weakens,[24] bringing us back to a configuration in which strongly localised, autonomous and separated (amongst each other) properties and functions precede the assemblage even by exhibiting emergent, interactive and transformative behaviours. The same pyramidal representation suggested by Hayles (*Ibid*.) to portray her relational scheme between cognitive processes-materialities and (human) consciousness does not give up with a verticality of ontological and performative differences[25].

Following more faithfully the deleuzo-guattarian machine, Sampson (2017) further advances the proposal of an

[22] According to Hayles, properties of such assemblages are the ones of "flexibility, adaptability, [and] evolvability" (2017, p. 31).

[23] Once cognition has been posited as a primary analytic category, Hayles (2017) suggests to substitute the human/non-human distinction with the *cognizers* versus *noncognizers*. In this new distinction, the latter category includes material processes and inanimate objects. Moreover, the first ones are categorised as actors whilst the second ones as agents (for details see pp. 30–33).

[24] For a discussion of eco-ontology see Marchesini (2018).

[25] In a preventive way, Hayles' proposal (2017) seems to pay the price for the "particular" complexity of human-animals (see also Hayles and Lulli, 2022, p. 53).

assemblage brain, suggesting that an emergent perspective of conscious subjectivity can be grounded on a becoming-brain of the self: a perspective that will thus imply a dimension that is already-distributed and pre-subjective – on an intensive level (and not strictly on a "non-conscious" one). Within the assemblage brain, relationality is highlighted, pushing the understanding of a cognition that can move beyond the neural barriers towards an ecology of encounters that are productive of cognition.

More in detail, beyond the anti-locationist and deleuzo-guattarian-inspired viewpoint, Sampson's conceptualisation of an assemblage brain (2017) develops some panpsychist theoretical trajectories that were already at stake in Henri Bergson's (1990) and Gabriel Tarde's (1903; 2012) works. Such conceptualisation strongly suggests the idea that "what becomes brain matter does not need to begin in a location or with a neuron at all" (Sampson, 2017, p. xv). This means that cognitive processes can also happen without a clear intentionality to produce meaning[26]; further, non-human individuations can surely make sense for their own existence, without necessarily having access to neurons[27]. Therefore, the cognitive one, or the "becoming-brain" (to say it with Deleuze and Guattari), is not a compulsorily located process, a process that is confined in a cellular organism. Indeed, agential forces of inorganic matter – as in the case of atoms or molecules of specific substances – can produce a sense in their own existence: they can be co-producers of, and – at the same time – reciprocally involved in, existential cognitive processes; and can perform such an emergent cognitive processuality – we highlight this again – without necessarily having neurons or a nervous system.

Sampson's (2017) assemblage brain can thus be mapped in all the micro-brains of organic and inorganic matter: not just because they can or cannot be able "to think" – but since potentially (on an intensive domain, in an affective and pre-individual/pre-subjective, and thus collective, regime) they are already (that is, "virtually") part of a relation that might generate processes of sense production, of *relationally* becoming-brain. On the monist and materico plane that has been mapped by Deleuze and Guattari (1987; 1994), cognition – being assembled – collectively coexists in the same perceptive and agentially-active variations of non-strictly nervous systems. The localisation of a cognitive process, in the here and now of a neuron or a synaptic connection, can only be a shelter: an umbrella for a cogito that becomes subject in order to affirm itself in its individuated subjectivation rather than accepting the partial and conjunctive dimension of the assemblage of which it is just an indivisible variation.

Conclusion, or the materialist dissemination and confusion of cognition

In the introductory part of this article we introduced some recent examples that approached the study of intelligence – technological and biological, non-human and vegetal – by centring their attention on cognition with the aim to reproduce and emulate it. The locationist proposal has been thus discussed as a conceptual ground on which cognitive sciences, in their phase of affirmation as a scientific discipline, have been building their long-lived models and convincing hypotheses. Nowadays, these assumptions resist and inspire the main interdisciplinary trajectories of the research on cognition, despite the rise of comparative studies that have been moving their attention towards a plurality of brains and intelligences beyond the human one. This attention

[26] As for instance happens with cellular proliferation in an embryo.
[27] In this case, Sampson (2017) mentions sea sponges and slime moulds.

highlights the conceptual limits of a neuro-centred framework, and strengthens the central position of a complex and co-determinant milieu that surmounts any disposition towards the organism-environment, mind-body, and/or I-world dualisms. Rather, an assembled cognition – an ecological one – of cognitive processes, starting from the premise of the relational emergence of the here and now of cognition, allows the overcoming of the obstacles of localisation, further emphasising the relevance of its pre-individuated (un-thought and intensive) dimension.

Partially continuing the exploration initiated by the externalist perspectives[28], in constant dialogue with the new materialist proposals (DeLanda, 1997; Barad, 2007; Bennett, 2010), and the posthuman approach (Marchesini, 2002; Braidotti, 2013), we suggest that cognition does not end to be one amongst the many properties of a body, system amongst the systems that are able to solve biologically-individuated functions, and is not necessarily and exclusively localised in the brain or nervous system of that body. We think of cognition as a plural, collective process that involves a multiplicity of bodies and chronotopies instead: a distributed becoming (also intensively, anticipating the ontogenetic processes of individuation) that blossoms with/in matter – that is an assemblage of complex relations and conjunctions in which ontic singularities and specificities are not nodes within a network, isolated and autonomous even if interconnected monads, but ontological deviations, contaminated protrusions, stratifications of an intimate and deep materico-hybridisation.

Such a conceptualisation of cognitive processes allows us: on the one hand, to rethink the relation between the body and their manifestation through such behaviours that we openly describe as "intelligent" ones; on the other hand, it allows to re-devise the same idea of mind and its relation with the world. The concept of intelligence strengthens itself. It becomes something more than the ingenuity of a body that is able to solve the problems that are posited by a pre-supposed "environment", or the ability to posit such problems and comprehend their same problematic relevance (Marchesini, 2008). Rather, it becomes the *possibility to create problems, a problematic-world-becoming* – that is a movement on the same material, onto-epistemological and ethical plane on which this existential take of intelligent individuation happens[29]. In the case of the human-animal, the vibration between conscious and unconscious processes, between redundancy and resonance, pushes to the devising of a mind that inevitably must contemplate something else, and beyond, her own skull, his own brain, their own selves: a mind that is an ecology, a mind that we define as being *confused* and *disseminated*.

The tentacles of an *Octopus vulgaris*, as the spines of an *Opuntia microdasys*, or the microchip of a drone, from mere anatomic-mechanic protuberances, simple accessory and functional limbs, transmute in disseminated cognition. The processual description of those circuits, thorns or suckers changes as well: from an available tool of the machine, cephalopod or plant, an instrument that is useful to solve a problem, they become siliceous vectors, tentacular and stinging protuberances that are able to generate, become a problem together with the organic and inorganic materialities that, once individuated, sustain their co-constitution[30]. By manipulating coconuts, firing germinative bio-capsules, or holding humidity – tasks that

[28] See footnote 3.

[29] For a summary of the problem of intelligence in posthumanist studies see Macelloni (2021).

[30] For a better comprehension of our way of conceptualising the intersection of diverse materialities on a plane of consistency see Micali and Pasqualini (2018; 2019).

are needed for survival – the cephalopod, as the drone and *opuntia* are relational catalysers in-becoming: zoetic disseminators of problems, variations of concatenated assemblages of biotic and abiotic materialities. Solving problems – the becoming-brain of embodied cognition – is consubstantial to the same being of a problem: matter, as such, becomes an onto-epistemological dilemma of the world.

When the "environment" stops to be accounted for as a plain reservoir of stimuli, or a passive container/content available for the interpretation and shaping of brains that are not anymore self-autonomous, discrete and isolated onto-epistemological synthesisers of non-human materialities, how can we rethink the relational, ecological element at the core of such a conceptual movement?

Our proposal implies that cognitive processes do not just cut across the individual by actively and consubstantially involving the world into which they are embodied, but also challenge and overcome a computational-alike understanding, and a need to exclusively posit processuality in terms of motion. The hybrid and transformative configuration we are proposing for cognition, as of the bodies into which it might find temporary co-emergence, aims to stress the multiplicity of co-presences and involvements that, underlying cognitive processes, are not only somatic but operative as well. Our proposition also challenges the assumption that in order to find cognition we should look into a brain, its connections and/or its cells, signalling this as an illusionary and reductionist attempt: a motion-centred framework to understand process-led distribution, which seems to be equally misleading.

The movement-action, movement-interaction pairings are logical and intuitive assumptions, obvious couplings that any scientific investigation takes for granted. The value of agentiality of inert bodies and their static "being" is often neglected, negating the contribution and participation that they bring into a relational plane into which matter intra-acts (Barad, 2007). Such an assumption is so rooted that it is easy to meet speculations about the energy-transmitting power of rocks, or the speaking abilities of tree logs: attempts to biomorphise static matter, a vitalising reprogramming that distributes relational potentials of higher or lower quality, attributing and creating performativity where only mute and sterile immobility was present. As discussed in the introduction, it is key to highlight that many efforts of the Western scientific-technological complex are directed to biomimesis, the emulation and increase of biological capabilities. The narcissistic ambition to see animal-like behaviours being replicated by a specific material or a technology informs many of the discussed examples in current research strands. Technological individuations are the embodiment of the becoming-problem through which we have attempted to grasp cognition: it is already melted with the flash, fibres or alloys with which it assembles, solving problems and becoming itself a problem. Cognitive processes are as such promiscuous, deeply contaminated and confused, but also disseminated, strata.

The term "confused" sustains the conceptualisation of a thought that, according to our proposal, surfaces in a hybrid and contaminated process: "con"-fusion as a shared fusion of multiplicities that are an onto-epistemological consistency. Further, the adjective 'disseminated' aims to overcome the idea of a (localisable) point of origin – from which cognition departs or distributes from (as for instance in Edwin Hutchins' distributed cognition; 1996), extends from (as in Andy Clark and David Chalmers' extended mind; 1998), or broadens (as in Riccardo Manzotti's spread mind; 2017). On such a standpoint, "dissemination" recalls the idea of something

that is scattered, like plant seeds that, even though are contained in one amongst many ripe fruits, are ready-to-blossom "problems" (intensively-ready problems – disseminated over different threshold of possibility and virtuality as well). To be more precise about the relational threshold of our proposal, we aim not to step into a form of panpsychism into which indiscriminately everything has a mind, or everything is thinking. A panpsychic framework implies, in fact, that the mind, or more broadly cognitive processes, are an attribute of an entity, a quality of each entity; on the contrary, we assume cognition as being an occurrence: the blossoming emergence of a series of possibilities, the surfacing – constantly renovating and in transformation – deviation of a mixture between diverse and different materialities.

Nevertheless, as anticipated above, a disseminated and confused comprehension of cognition that surfaces form a hybrid and relational individuation of embodied matter, suggests a processuality that is not exclusively situated in a body, but that con-fuses with other bodies and amongst their relations – relations that cannot be merely reduced to a movement of exchange and assimilation of information, being capable to foster and recognise some other forms of motionless agentiality instead. Even though disseminated cognition obviously recalls some already mentioned positions that are often labelled as 'externalist', we insist on the need to approach cognitive processes beyond binary and dichotomic viewpoints such as the subject/world one, or exclusive, moving and active dynamics such as the in/out, and stimulus/response ones. This means to more deeply apprehend the surrounding that is often defined and characterised as "external" in regards to us, to our situated and embodied individuation. It is thus crucial, in order to understand cognitive processes, to think that they do not necessarily depart from, and end into, a clear-cut and exact centre. Cognition does not unfold into a so-called, and pre-existing "environment" by encountering, attracting or repelling the alterities with whom it enters in relation and from which it is waved of stimuli that can be archived, deciphered and ordered. The conceptualisation of a disseminated cognition recalls a more scattered configuration, a more chaotic or "chaosmotic" (to say it with Guattari, 1995) material arrangement instead: an assemblage that is more than just diffused or distributed, but a stratified, anti-hierarchic and blossoming disposition, which can be mapped and partially discerned, bringing further confusion to the same cognitive effort that attempts to grasp it.

Bibliography

Abu-Hassan, Kamal, Taylor, Joseph D., Morris, Paul G., Donati, Elisa, Bortolotto, Zuner A., Indiveri, Giacomo, Paton, Julian F. R., & Nogaret, Alain (2019). Optimal Solid State Neurons. *Nature Communication*, 10(1), 1–13.

Alpi, Amedeo et al. (2007). Plant Neurobiology: No Brain, No Gain?. *Trends in Plant Science*, 12(4), 135–136.

Airseedtech (n.d.). *AirSeed Home*. Retrieved May 15, 2022. https://airseedtech.com/

Ammaniti, Massimo, and Gallese, V. (2014). *The Birth of Intersubjectivity: Psychodynamics, Neurobiology, and the Self*. WW Norton & Company.

Andrejevic, Mark (2020). *Automated Media*. Routledge.

Auletta, Gennaro (2011). *Cognitive Biology: Dealing with Information from Bacteria to Minds*. Oxford University Press.

Azad, Abul Kalam; Barthlott, Wilhelm, and Koch, Kerstin (2015). Hierarchical Surface Architecture of Plants as an Inspiration for Biomimetic Fog Collectors. *Langmuir: the ACS journal of surfaces and colloids*, 31(48), 13172–79.

Bai, Fan; Wu, Juntao; Gong, Guangming, and Guo, Lin (2015). Biomimetic "Cactus Spine" with Hierarchical Groove Structure for Efficient Fog Collection. *Advanced Science*, 2(7), 1500047. https://doi.org/10.1002/advs.201500047

Barad, Karen (2007). *Meeting the Universe Halfway. Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press.

Bennett, Jane (2010). *Vibrant Matter: A Political Ecology of Things*. Duke University Press.

Bergson, Henri (1990). *Matter and Memory*. Zone Books.

Bechtel, William, Abrahamsen, Adele, & Graham, George (1998). The Life of Cognitive Science. In William Bechtel, Adele Abrahamsen, & George Graham (Eds.), *A Companion to Cognitive Science* (pp. 1–104). Blackwell.

Braidotti, Rosi (2013). The *Posthuman*. Polity Press.

Broussard, Meredith (2018). *Artificial Unintelligence. How Computers Misunderstand the World*. MIT Press.

Calvo Garzon, Francisco (2007). The quest for cognition in plant neurobiology. *Plant signaling & behavior*, 2(4), 208–211. https://doi.org/10.4161/psb.2.4.4470

Castiello, Umberto (2019). *La mente delle piante. Introduzione alla psicologia vegetale.* Il Mulino.

Clark, Andy (1997). *Being There: Putting Brain, Body, and World Together Again*. MIT Press.

Clark, Andy, and Chalmers, David J. (1998). The Extended Mind, *Analysis*, 58(1), 7–19.

Cohen, Jeffrey J. (2013). *Prismatic Ecology. Ecotheory Beyond Green*. University of Minnesota Press.

Couldry, Nick, & Mejias, Ulises A. (2019). *The Costs of Connection. How Data Is Colonizing Human Life and Appropriating It for Capitalism*. Stanford University Press.

Crawford, Kate (2021). *Atlas of AI. Power, Politics, and the Planetary Costs of Artificial Intelligence.* Yale University Press.

Curry Jansen, Sue (2022). *What Was Artificial Intelligence?* Mediastudies.press.

D'Alessandro, Jaime (2022, May 09). Droni e Intelligenza Artificiale per Piantare 100 Milioni di Alberi. *La Repubblica*. https://www.repubblica.it/green-and-blue/2022/05/09/news/airseed_droni_intelligenza_artificiale_alberi_piante_habitat- 348365486

Damasio, Antonio (1999). *The Feeling of What Happens. Houghton Mifflin Harcourt*.

Damasio, Antonio (2003). *Damasio, Antonio. Looking for Spinoza. Carlisle & Company*.

Damasio, Antonio (2006). *Descartes' Error*. Random House.

Daston, Lorraine (1997). Die Quantifizierung der weiblichen Intelligenz. In Renate Tobies (Eds.), *Aller Männerkultur zum Trotz: Frauen in Mathematik und Naturwissenschaften* (pp. 69–82). Campus-Verlag.

Dębiec, Jacek; Heller, Michał; Brożek, Bartosz, and LeDoux, Joseph (2014). *The Emotional Brain Revisited*. Copernicus Center Press.

DeLanda, Manuel (1997). *Thousand Years of Nonlinear History*. Zone Books.

Deleuze, Gilles, and Guattari, Félix (1983). *Anti-Oedipus.* University of Minnesota Press.

Deleuze, Gilles, and Guattari, Félix (1986). *Kafka: Toward a Minor Literature.* University of Minnesota Press.

Deleuze, Gilles, & Guattari, Félix (1987). *A Thousand Plateau*. University of Minnesota Press.

Deleuze, Gilles, & Guattari, Félix (1994). *What is Philosophy?* Columbia University Press.

Dreyfus, Hubert (1972). *What Computers Can't Do. Harpers & Row*.

Fayemi, Pierre-Emmanuel; Wanieck, Kristina; Zollfrank, C.; Maranzana, Nicolas, and Aoussat, Améziane (2017). Biomimetics: Process, Tools and Practice. *Bioinspiration & Biomimetics*, 12(1), 20.

Gagliano, Monica (2017). The Mind of Plants: Thinking the Unthinkable. *Communicative & integrative biology*, 10(2), 38427. https://doi.org/10.1080/19420889.2017.1288333

Gibbs, Raymond W. (2006). *Embodiment and Cognitive Science*. Cambridge University Press.

Gibson, James J. (1950). *The Perception of the Visual World*. Houghton Mifflin.

Gibson, James J. (1979). *The Ecological Approach to Visual Perception*. Houghton Mifflin.

Gibson, James J. (1966). *The Senses Considered as Perceptual Systems.* Houghton Mifflin.

Godfrey-Smith, Peter (2018). *Other Minds*. Farrar, Straus & Giroux.

Goleman, Daniel (1995). *Emotional Intelligence*. Bantam Books.

Guattari, Félix (1995). *Chaosmosis: An Ethico-Aesthetic Paradigm*. Indiana University Press.

Hayles, N. Katherine (2017). Unthought. The Power of the Cognitive Nonconscious. University of Chicago Press.

Hayles, N. Katherine, & Lulli, Ambra (2022). L'Impensato. Intervista a N. Katherine Hayles *Philosophy Kitchen*. https://philosophykitchen.com/tag/impensato/

Hutchins, Edwin (1996). *Cognition in the Wild*. MIT Press.

Klumbyté, Goda (2018). Extended Cognition. In Rosi Braidotti & Maria Hlavajova (Eds.), *Posthuman Glossary* (pp. 148–150). Bloomsbury Academic.

Kurzweil, Ray (2012). *How to Create a Mind. The Secret of Human Thought Revealed*. Viking Books.

Lakoff, George, & Johnson, Mark (1999). *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. Basic Books.

Latour, Bruno (2005). *Reassembling the Social. An introduction to Actor-Network Theory*. Oxford University Press.

LeDoux, Joseph (2002). *Synaptic Self*. Viking.

LeDoux, Joseph (2015). *Anxious*. Simon and Schuster.

Macelloni, Manuela (2021). Intelligenza. In Elisa Baioni, Lidia Maria Cuadrado Payeras, & Manuela Macelloni (Eds.), *Abbecedario del Postumanesimo* (pp. 222–223). Mimesis.

Malafouris, Lambros (2013). *How Things Shape the Mind*. MIT Press.

Mancuso, Stefano, and Viola, Alessandra (2015). *Brilliant Green*. Island Press.

Manzotti, Riccardo (2017). *The spread mind.* Or Books.

Marchesini, Roberto (2002). *Post-human. Verso Nuovi Modelli di Esistenza.* Bollati Boringhieri.

Marchesini, Roberto (2008). *Intelligenze plurime. Manuale di Scienze Cognitive Animali.* Alberto Perdisia Editore.

Marchesini, Roberto (2018). *Eco-ontologia. L'Essere Come Relazione*. Safarà Editore.

Mazzolai, Barbara; Beccai, Lucia, and Mattoli, Virgilio (2014). Plants as Model in Biomimetics and Biorobotics: new perspectives. *Frontiers in bioengineering and biotechnology*, 2, 2. https://doi.org/10.3389/fbioe.2014.00002

Micali, Alberto, and Pasqualini, Nicolò (2018). Excavating the Centrality of Materiality for a Post-human 'Anthropomediality': an Ecological Approach, *Journal of Posthuman Studies*, 2 (1), 6–27.

Micali, Alberto, and Pasqualini, Nicolò (2019). Posthuman Aesthetics: Perception and Relationality, Mapping the Field Through the Lens of Critical Posthumanism. *Scenari*, 10, 133–160.

Miller, Melissa B., and Bassler, Bonnie L. (2001). Quorum Sensing in Bacteria. *Annual Review of Microbiology*, 55, 165–199.

O'Neil, Cathy (2016). *Weapons of Math Destruction. How Big Data Increases Inequality and Threatens Democracy*. Crown.

Parise, André Geremia; Gagliano, Monica, and Souza, Gustavo Maia (2020). Extended Cognition in Plants: Is it Possible? *Plant signaling & behavior*, 15(2), 1710661. https://doi.org/10.1080/15592324.2019.1710661

Phillips, John (2006). Agencement/Assemblage. *Theory, Culture & Society*, 23(2–3), 108–109.

Rowlands, Mark (2003). *Externalism. Putting Mind and World Back Together Again*. Acumen Publishing Limited.

Rupert, Robert D. (2009). *Cognitive Systems and the Extended Mind*. Oxford University Press.

Sampson, Tony D. (2017). *The Assemblage Brain. Sense Making in Neuroculture*. University of Minnesota Press.

Simondon, Gilbert (1989). *L'individuation psychique et collective*. Editions Aubier.

Simondon, Gilbert (2017). *On the Mode of Existence of Technical Objects*. University of Minnesota Press.

Speck, Olga; Speck, David; Horn, Rafael; Gantner, Johannes, and Sedlbauer, Klaus Peter (2017). Biomimetic Bio-inspired Biomorph Sustainable? An Attempt to Classify and Clarify Biology-derived Technical Developments. *Bioinspiration & Biomimetics*, 12(01), 011004. https://doi.org/10.1088/1748-3190/12/1/011004

Speck, Olga, and Speck, Thomas (2021). Functional Morphology of Plants – a Key to Biomimetic Applications, *New Phytologist*, 231(3), 950–956.

Spinoza, Baruch (1996). *Ethics.* Penguin.

Stamenov, Maksim I., and Gallese, Vittorio (Eds.) (2002). *Mirror Neurons and the Evolution of Brain and Language*. John Benjamins Publishing Company.

Taiz, Lincoln; Alkon, Daniel; Draguhn, Andreas; Angus, Murphy; Blatt, Michael; Hawes, Chris; Thiel, Gerhard, and Robinson, David G. (2019). Plants Neither Possess nor Require Consciousness. *Trends in Plant Science*, 24(8), 677–687.

Tarde, Gabriel (1903). *Laws of Imitation*. Mershon Company Press.

Tarde, Gabriel (2012). *Monadology and Sociology*. Re.Press.

The Telegraph (2008, October 31). *Otto the Octopus Wreaks Havoc*, www.telegraph.co.uk/news/newstopics/howaboutthat/3328480/Otto-the-octopus-wrecks-havoc.html

Turing, Alan M. (1950). Computing Machinery and Intelligence. *Mind*, 49, 433–460.

Varela, Francisco J;, Thompson, Evan, and Rosch, Eleanor (1991). *The Embodied Mind. Cognitive Science and Human Experience.* MIT Press.

Von Neumann, J. (2012). *The Computer and the Brain*. Yale University Press. (Original work published 1958).

Whitehead, Alfred North (1978). *Process and Reality*. The Free Press.

Zhu, Hai; Guo, Zhiguang, and Liu, Weimin (2016). Biomimetic Water-collecting Materials Inspired by Nature. *Chemical communications*, 52(20), 3863–3879 . https://doi.org/10.1039/C5CC09867J

Zuboff, Shoshana (2019). *The Age of Surveillance Capitalism*. Public Affairs.

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