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Embodiment: The Ecology of Mind

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Abstract: Following a suggestion from G. Bateson, this article enquires into the consequence of the idea of embodiment in philosophy of mind, taking seriously the notion of an ecology of mind. In the first half of this article, after distinguishing between the biological and the systemic approaches to ecology, I focus on three characteristics of the systemic approach. First, that a system is an abstract object that is multiply embodied in a collection of physically distinct heterogeneous objects. Second, that there is a form of circular causality between the level of the elements and that of the system as a whole, as some characteristics of the elements partake in the explanation of how the system functions, while the requirement of the system explains why the elements have the characteristics that they do. The third is the ontological uncertainty that we sometimes find in ecology, where the same term is used to designate both a central component of the ecological system and the system as a whole. In the second half, beginning with a critique of the theory of mind approach, I look into the consequences of conceiving that mind is embodied in a collection of physically distinct heterogeneous objects that interact as elements of a system, rather than enclosed in an individual body.

Keywords: autonomous system; autopoietis system; Bateson; children; cognitive ecology; ecology; niche; theory of mind

1. The Ecology of Mind

In 1972, Gregory Bateson published *Steps to an Ecology of Mind* [1]. "Steps" seems the right title for a collection of essays written over a period of more than thirty-five years, in which the idea of an ecology of mind only becomes an explicit theme in the last section of the book. What these steps recount is how Bateson, who was throughout his life "concerned by four sorts of subject matter: anthropology, psychiatry, biological evolution and genetics, and the new epistemology which comes out of systems theory and ecology", progressively became convinced that ideas and mind cannot be studied and understood in isolation, but only as part of a larger system. Thus, the idea of an "ecology of mind", that there is an ecosystem of mind and ideas. In this contribution, I wish to revisit not so much Bateson's text, as the idea of an ecology of mind in relation to the question of embodiment.

The project faces an immediate objection: during the last twenty years or so, the term ecology has been used in relation to so many different topics that its meaning has become, to say the least, somewhat unclear. For example, a quick search for the entry "ecology of" in open access website Academia.edu gives, apart from the ecology of various animals, plants, viruses, and types of environment among others, the following results: the ecology of tactical overlap [2], the ecology of affect [3], the ecology of terror defense [4], the dark ecology of elegy, the ecology of religious beliefs, of medieval art, of team science, of risk taking, of monads, of technology, of recovery, of Victorian fiction, of narratives, and so on. Given this abundance of associations, it is difficult to understand what the ecology of mind could mean or how it can be more than just another metaphor.

In biology, ecology is usually defined as the branch which studies how organisms interact with their environment and with other organisms. Each individual entertains complex relationships with

organisms of both its own and other species, as well as with its abiotic environment. These interactions constitute selective pressures that lead to the adaptation of individuals and the evolution of species. Ecology is the study of these complex relationships among different organisms, with non-living factors of the environment, and the resulting selective pressures [5][1]. Ecology, however, is also understood as the study of the system formed by the relationships between plants, animals, people, and the environment, as well as the equilibria or at least the balances between these various elements. The two meanings, though closely related, are not identical; while ecology in its biological sense focuses on the relations between an organism or species and its environment, the systemic approach centers on the complex system that organisms constitute together with their environment. In this second sense, there is not only the ecology of various organisms, but also of particular places, like Lake Victoria, or of typical environments, for example the ecology of desert landscapes or of wetlands. In the systemic sense, organisms and their environment are viewed as one complex system rather than as two independent objects that interact.

Since Bateson published *Steps to an Ecology of Mind*, a new discipline, cognitive ecology, began addressing some of the questions that interested him. Cognitive ecology enquires into the way the environment shapes an individual organism or species cognitive traits and behavior, including how selective pressures from the environment mould an organism's brain. Its approach is mostly comparative, as this influence of the environment is particularly striking in two types of cases. First, when closely related species (or different populations of the same species) who inhabit different ecologies have cognitive abilities that diverge. Second, when distantly related species found in similar ecologies manifest cognitive convergence [6]. In both cases, the environment's pressures on the organisms' cognitive traits seem evident. Cognitive ecology thus views the cognitive traits of organisms as adaptations to different environments and seeks to understand the selective pressures that lead to different adaptations. It is a sub-discipline of biology and clearly belongs to ecology in the first sense identified above. It extends to brain and cognition the classic adaptationist research program; inquiring into the way environmental pressures influence the cognitive ability of organisms.

Bateson was, of course, interested in how the mind, for example that of a schizophrenic, becomes adapted to his or her environment [7][2], but he also argued that the mind should be seen as a complex system, rather than treated as a collection of cognitive traits that can be matched to various selective pressures. Viewing mind as a complex system is different from seeing *a* mind or *the* mind as a set of adaptations to a particular environment, adaptations that are embedded in an individual's brain or manifested in his or her behavior. One of the reasons why this is so, is because a system, rather than a material thing, is an abstract entity that is inevitably 'embodied' in a collection of heterogeneous physically distinct objects. What image of the mind arises if we take seriously the idea of an ecology of mind in the systemic sense? What are the consequences of such an approach to the idea of embodiment in philosophy of mind?

2. System and Elements

The ecology of any item x, whatever x may be, a lake, a bat, or mind understood in the systemic sense assumes as methodological point of departure that the item and its environment form a complex (eco)system. Of that ecosystem, x itself constitutes, but one element, among others—that is not independent from the rest of the system and whose properties and characteristics cannot be understood without taking the whole system into account. In many cases, the ecology of x implies more: that there is a sense in which x does not exist outside of the system of which it is a part, because the role that x plays within the system is what explains and determines that its characteristics are what they are.

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[1] See for example, the entry ecology in the *Biology Dictionary* https://biologydictionary.net/ecology/.

[2] See for example, G. Bateson, D. D. Jackson, J. Haley & J. H. Weakland, "Towards a Theory of Schizophrenia" in *Behavioral Science*, 1:4, 1956. Reprinted in *Steps to an Ecology of Mind*, pp. 201–227.

At first sight, this presents a difficulty. The system as a whole is viewed as explaining the properties of x, but x is a central element of the system. As such, x's properties enter into the explanation of how the system works and is maintained. In consequence, the properties of x become part of the explanation of the properties of x. This seems like a perfectly vicious circle, but is it? More generally, the difficulty can be formulated in the following way: Can an element of a system be viewed as the result, or as an effect of the functioning of the system of which it is a part? To the extent that it is strictly taken as an element of the system, rather than as this or that object or organism, the answer is evidently "yes". Any object has a large number of properties, not all of which may be relevant to its role as an element of a system; depending on what the system is, the object's color, its shape or its chemical composition will or will not be relevant. The system 'chooses' in a metaphorical sense, or focuses on some properties of the object, which are essential to its functional role within the system.

In the case of human made systems, this is obviously true. The (idea of the) system determines it is the reason why the different elements of the system have the required characteristics to be parts of the system. Not only is the wheel of a car or the handle of a door only such if there is a car or door of which it is the wheel or handle, but their particular characteristics are determined by the requirements of the specific (type of) car or door of which they are part. Something similar is true of some natural systems: the system itself is responsible for the production and crafting of the elements that ensure its continued existence. This circular relation of causality constitutes a fixed point in the system's behavior and a mechanism that ensures its stability.

For example, organisms interact with their environment; they take energy and resources, make habitat choices, sometimes construct artifacts, inevitably emit detritus, and die in the environment. All of these, the actions of organisms and the accidents that befall them, modify the natural selection pressures in their environment; this in turn adapts the organisms to the environment which their activity of niche construction transforms [8,9][3]. A circular causal relation between niche construction and adaptations that leads to a form of equilibrium becomes established. In consequence, if the environment to which the organisms are adapted and which they partially moulded to suit themselves is radically changed, the organisms will disappear. They will either die or if they can adapt to this new environment; they may become quite different, unrecognizable, a new species [10]. Alternatively, eradicate the species, and the environment will be profoundly changed.

This circular causal structure is reminiscent of how Varela and Maturana define an autopoietic system: as a closed network of processes, which produce through their interactions the elements that make up the network and the relations that define it [11]. As long as the perturbations to which the system is subjected remain within a certain range, it will succeed in producing the conditions that favor its continued existence. As its name indicates, an autopoietic system is a system that produces itself, that functions in such a way that it generates the various elements that enter into its composition and maintains among them the relations that define it. In this case, it is not only the characteristics of the elements, but their very existence that result from the functioning of the system.

According to Varela, an autopoietic system, as opposed to an autonomous system, is characterized by the fact that the closure of the network of production coincides with a border in physical space, which separates what is inside from what is outside the system [12]. It is clear that in ecological systems, this condition is not satisfied; but they may be considered to be autonomous systems to the extent that they often exhibit a form of circular causality, especially between niche construction and adaptations, which ensures the stability and permanence of the system. The organisms are adapted to the characteristics of the ecological niche that, given their adaptations, they reproduce, while selective pressures in the niche favor individuals who have these very adaptations.

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[3] F. J. Odling-Smee, K. N. Laland & M. W. Feldman, *Niche Construction. The Neglected Process in Evolution*, Princeton University Press, 2003. The importance of this circular relationship between niche construction and adaptation was originally pointed out by R. Levins & R. Lewontin in their book *The Dialectical Biologist*, Harvard University Press, 1985.

The failure of autonomous systems to produce a clear border that allows the observer to distinguish between the system and its outside has an important consequence[4]. The ecosystem tends to be identified through the central item of which it is the ecosystem, because there is no easy (and no better way) to discover what is and what is not part of the system. In the ecology of a lake for example, the lake will appear as both an enclosed body of water and as the whole ecological system of the lake, of which the enclosed body of water constitute but one, albeit fundamental, element. The ecological system will include apart from the enclosed body of water, things such as the flora and fauna found there, migrating birds, if its bank are steep or gentle slopes, the number of tourists who walk on its shores, and so on. This creates an ontological uncertainty that we are usually ready to accept. We have no qualms in assuming that the lake is both the enclosed body of water and the whole ecological system, for that whole system is what makes the lake what it is, that which determines its ipseity. If the ecological system were different, the lake would not be the same. We have no difficulty in considering that the lake is both an element of the ecosystem and that, in a sense, it is the ecosystem as a whole. Yet, we do not recognize migrating birds or the surrounding flora as part of the lake, though they clearly are elements of the ecosystem.

Thus, the idea of an ecology of mind entails three closely related postulates. First, that there is a form of circular causality between the level of the central component, individual minds, and the system as a whole, which is responsible for the characteristics of the elements that are indispensable to the maintenance of the system. Second, that the system is 'embodied' through a collection of physically distinct heterogeneous objects (or bodies). Finally, that there is ontological uncertainty between minds at the individual level, as an element of the system, and mind at the level of the system as a whole.

3. Ecology and the Theory of the Theory of Mind

The hypothesis that we attribute to others a mind like our own, rather than we discover that they have a mind is often referred to as the "theory of the theory of mind". A "theory", because it is assumed that we cannot perceive directly the mind of others and therefore this attribution constitutes a theoretical hypothesis that we make to explain their outward behavior. And this theory may be called a "theory of mind" since its content is that others have a mind. Though the theory of the theory of mind is not usually seen as an approach to the question of embodiment, one of its central presupposition is that the individual's mind is enclosed in his or her body, perhaps more precisely in the brain of the agent. Depending on one's philosophical leaning, the body, as opposed to the brain alone, may also be seen as more or less important to the agent's cognitive ability and mind, but in any case, an essential aspect of all such approaches is that they view the mind as individually embodied.

Any approach that adopts the theory of mind in one form or another assumes, in agreement with much of philosophy, that the body constitutes some kind of obstacle, which prevents minds from being in direct contact, a veil behind which the individual's mind is hidden or a prison that condemns it to solitary confinement. That is the very reason why seeing others as having a mind must be a theoretical hypothesis, since this 'immaterial stuff' is not something that can be perceived directly. Whether they like it or not, or are aware of it, advocates of the theory of mind accept a basic premise of dualism in philosophy of mind. The invisibility and public inaccessibility of mind construed as a private essentially subjective phenomenon. To the opposite, the idea that mind is not individually, but multiply embodied suggests that the experience of mind extends beyond the limit of what is merely subjective and private.

One important question in the theory of the theory of mind is to determine at what point in development a child becomes able to attribute to others complex mental states, which is to say at

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[4] It may be that the coincidence of the closure of the system with a clear border in physical space in a physical system, like a cell, is made possible because in such systems the production of the elements is inseparable from generating the rules of their interactions since, their interactions, for example in the case of proteins, depend directly on the shape and chemical reactivity of the molecules produced by the cell.

what stage does he or she develop a theory of mind. There exists a well-established experimental protocol according to which the ability to attribute false beliefs to others, in order to explain or predict their behavior, indicates the moment when a child is able to recognize that others also have a mind just like he or she does, that the other is an agent whose actions are guided by his or her own beliefs and desires.

Beyond the many critiques of this experimental set up, in particular concerning its ability to clearly determine that moment, Micheal Tomasello raises a more fundamental problem. In order to attribute false beliefs to others, a child must already have a concept of false beliefs. In order to develop a "theory of mind", a child must already have a concept mind of which the concept of beliefs which may sometimes be false and sometimes true constitutes a central element. Yet, adds Tomasello, we do not know how the child comes to acquire this notion of false belief. He suggests that the child develops this notion through social interactions in which he or she experiences being misunderstood [13]. Thus, according to Tomasello, this fundamental notion is not originally given to the child in an evident and immediately transparent way and then attributed to other. Rather, it is something that the child needs to construct and discover in his or her experience of the world and of others. When talking about adults, the idea that I have an immediate access to my own mind, and that on the basis of this internal knowledge I attribute to others a mind which I can never perceive directly, may sound convincing. However, we cannot assume that the child is born with direct immediate knowledge of his or her own mind. This is something that must be acquired during development; how does it happen?

When he explicates and tries to demonstrate his hypothesis, Tomasello presents the child as progressively learning that he or she can be misunderstood and can misunderstand others. In this learning process, the child is described more or less as what could be called a young "scientific observer" who tries to understand the world, who makes hypotheses, and attempts to verify them. The child then, according to this perspective, develops a concept of false beliefs through making hypotheses, analyzing the behavior of others and attributing them beliefs to finally discover that these beliefs may also be false. I am quite certain that this constitutes part of the process, but only one part.

Interacting with others is in fact quite different from merely observing them. To use a grammatical image, interaction takes place at the first and second person, rather than it corresponds to the third person position as observing does. When we interact with others we do not simply 'notice' or 'discover' that we were wrong, that others contradict us, that our desire has been frustrated or satisfied; we react and respond. The child laughs, smiles, cries or throws a fit. Some may want to argue that in order to react, one first needs to perceive and understand what is going on and therefore that observation and analysis must come first as necessary conditions.

Is this, however, really the case? Many studies on joint attention and imitation in very young children have shown that infants require and seek the attention of others to which they react; they enjoy it. Being attended to by another person is immediately for that child to be in contact and communication with that other. This contact and communication are not the transfer of information, rather it is for the child to have its state of being transformed. When, a little later, children become able to notice more generally where the other's attention is directed, they imitate them and turn their own attention towards the same object. It seems clear that very soon, shortly after their birth, children are able to distinguish between being the target or not being the target of the attention of others. It follows that their universe rapidly becomes populated by two very different types of entities, some, like humans and certain animals, that can take them as object of their attention and others, like a chair, a toy or a piano, that cannot. How does the infant gain that knowledge? By experiencing it, simply by being taken as the object of the attention of others.

Unlike observing, being taken as the target of the attention of another person is not something that a child does, it is something that is done to the child. Something of which the child becomes aware without any action on his or her part, and yet to which the child reacts. The expressions "being the target of" or "being taken as the object of" the attention of another are sufficiently vague to encompass what is involved here. They should be understood in a broad sense to include such things as holding

or carrying the child, taking to him or her, making faces, smiling, changing his or her diaper, helping and at other times preventing the child from doing or reaching something. 'Paying attention to the child' understood in this broad sense corresponds to a wide range of different intentions towards the child, but does not imply any one in particular. It nonetheless is an action that reveals its author as an intentional agent or at least as an entity that is radically distinct from many other objects in the world.

In consequence, the child's world is from the very beginning populated with "minds" that he or she 'perceives' directly whenever the child is taken as the target of the attention of others. Our world, the world of each one of us is from the origin full of beings that are able to take us as objects of their attention. Even if the young child does not know what a mind is, he or she is much more aware of their existence than of anything else in the world. The child's knowledge of such mindful creatures is much greater than he or she understands what a pencil or a frying pan is. The mind is not hidden in the nooks and cranny of the head or brain, but something public and social. Everyone can see it and all are invited to take part in it.

The individual's body therefore is not a black box in which the mind's algorithm, forever invisible to others, maps inputs onto outputs. It is open to others who act upon it and in doing so act on the embodied mind that we are. For us humans to be embodied is to be offered to the action and attention of others, which can not only harm us or satisfy our needs, but which also pleases us, or makes us sad, instills calm or anxiety, reassures or threatens. The actions of others upon us shape our psychological states and to do that, the 'action' of the other does not necessarily need to be anything in particular. It does not even need to be properly an action. The mere presence of some others can be enough to rejoice or make a child cry, and so can it also be with adults, though they may be loath to admit it.

4. Mind and the Open Body

The fact is that our mind is not merely embodied individually, but also commonly. Of course, our sensations, precepts or thoughts are our own, yet what they are, their content, is partially shaped by the presence and action of others. This is sometimes literally the case. Researches have shown that when an animal that has been wounded in an attack by a con-specific is consoled by another, the attention and caressing touch the chimp receives releases in its brain endorphin, which alleviates pain [14]. As this example clearly indicates, humans are not the only animals whose internal states are sensitive to action and presence of others. Members of these other species do not, however, develop a mind the way human do.

The fundamental question therefore is not "at what point does a child become able to attribute a mind to others?" but "at what point does a child become able to attribute mind to him or herself?" How do we come to attribute to ourselves such strange things as beliefs, desires, emotions and representations? How does a child discover that he or she has mental states that reveal the world, but always imperfectly; that always fail to some extent to reveal it as it really is. How does the child succeed to abstract or extract him or herself from the immediate experience of the world? These questions arise because knowledge and cognition are immediately of the world, rather than they are knowledge and cognition of one's own mental states. Knowledge is not primarily reflexive. As Vytgotsky notes in his research on the language of young children, at first, knowledge of the world is not distinguished from the world itself. The original experience is not that of one's mind but of being in the world [15].

How then do we succeed in taking distance from this primordial experience of the world? Why do we later come to identify ourselves with this capacity to maintain a distance from the world, come to consider our 'self', the ego, as this very capacity? How does knowledge become reflexive, how does it become about itself? Why and how does this dimension of knowledge, that it is about itself, gain precedence over it being about the world?

Descartes in his search for certain, infallible, knowledge imagined an "evil genius", an all-powerful being that used all its energy to deceive him. There isn't an evil genius in the environment of every child, but nonetheless all harbor at least one "all powerful" being that regularly shows the child to be

wrong in many different ways. He or she tells the child to stop, that no he cannot have anymore, that it is time to go, don't touch that, and so on. Progressively the child learns that he or she has internal states, mental states, desires and beliefs that are different from what the world is, and different from the beliefs and desires of others. Tomasello is perfectly right. It is through interacting with others that the child develops a concept of false beliefs. Yet, interacting with others is different from simply observing them or representing the world. Interaction implies that one is taken as the target of the action of another person or agent. It is a strange form of action of which one is simultaneously the agent and the patient. The child does not first discover his or her own mind, become aware of its central characteristics and then attribute to other mental states similar to his or her. Rather, the child progressively develops the ability to participate in mind by being taken as the target of the attention of others and by being made wrong.

This primacy of interaction, that Descartes denied while acknowledging its importance through the fiction of the evil genius [16], reveals that the subjective experience of "having a mind" does not reflect the structure of the processes that underlie it. This experience should not be taken as a guide to understand mind or its embodiment. "Having a mind" in the sense of the subjective experience of reflexive thinking comes from our common disposition to interact, to act upon each other. It proceeds from the fact that our body responds, in the sense that it is transformed as a result of being the patient of the attention of another. Each one directly experiences that action of others upon him or her. The private and subjective mind is constructed through an ecology of social public interactions with other mindful creatures. It does not constitute a primary experience or evidence, but is the result of past interactions and of the multiple embodiment of mind.

5. Conclusions

The next step would be to describe the specific characteristics of the ecology of mind that makes us, humans, into cognitive systems of a very particular type. What needs to be explained is why some other highly social primates, for example chimpanzees, fail to be socialized in mind the way human children are. This is much too ambitious a project to be carried out in one short article. However, two relatively recent books suggest the direction in which an answer to the last question may be found. Sarah Blaffer Hrdy, *Mothers and Others. The Evolutionary Origins of Mutual Understanding* [17] and Bernard Chapais, *Primeval Kinship. How Pair-Bonding Gave Birth to Human Society* [18], argue that the evolutionary trajectory of the human species was profoundly marked by small changes in the relations between mates (Chapais) and in the relations between parents and offspring (Hrdy) compared to what is found among our closest relatives.

In closing, two other issues need to be addressed. First, it is important to note that this hypothesis does not consider that mind is an emergent property of a social or ecological system. At least not in the sense in which emergent properties are generally understood in natural sciences or in self-organization explanations of biological phenomena. For example, in the self-organization explanation of termites' mound building, the ability to build a mound is not something that termites possess individually. It is only instanced at the system level, and is viewed as emergent, because at the individual level there is no property of the termite which corresponds to mound building. This property only appears at the system level as the result of simple rules of individual [19][5] behavior, rules which do not refer to mound building. Here to the opposite what is involved are characteristics of individuals. Even if it is the system as a whole that makes possible the existence of the characteristics of mind that in turn maintain that mindful system in existence, individual minds are not characteristics of the system,

[5] Entomologists generally agree that termites do not respond to social messages from other individuals but simply react to the consequence of the work done by another termite, a behavioral response that is called stigmergy, so that what is involved in mound building are individual rules of behavior rather than direct communication or coordination between individuals. See S. Camazine, J.-L. Deneubourg, N.R. Franks, J. Sneyd, G. Theraulaz & E. Bonabeau, *Self-Organization in Biological Systems*, Princeton University Press, 2001, pp. 23–24.

but of individuals. Therefore, mind should not be seen as an emergent characteristic of the system because unlike mound building, it exists as a characteristic of individuals rather than only appearing at the system level while absent at the individual level. Mind is simultaneously embodied at the individual level and at a collective level. It appears both as a central element of the ecosystem of mind and as the ecosystem itself.

Second, what are the consequences of such an approach for embodied AI and especially for social robotics as a form of socially embodied AI? Implicit in the ecological approach, and as clearly presupposed in the first paragraph of the conclusion, is the idea that there exist different types of cognitive systems whose characteristics are partially determined not only by the physical embodiment of individuals, but also by what may be called their ecological embodiment. If this is correct, it follows that social robotics should not only consider the importance of the physical embodiment of artificial social minds, but also the ecological dimension of mind. In other words, we need to focus, not only on the physical characteristics of robots, which has been the dominant approach until now, but also on their ability and role as part of the ecological system that is constituted of their interactions with their human partners as well as with each other and with different types of cognitive systems, natural and artificial. To put it otherwise, the ecological approach adds a dialectical dimension to social robotics, for it argues that it is not only the particular characteristics of artificial systems that determine social AI, but also the ecology of such systems and their partners, which determine the particular characteristics of the artificial systems involved. As Luisa Damiano and I have argued elsewhere, this is an ecology that is in the process of being built and it is important to understand from the beginning, the way in which these machines will change the social world and the way in which the social world will determines what these artificial systems are [20,21].

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References

1. Bateson, G. *Steps to an Ecology of Mind*; Ballantine Books: New York, NY, USA, 1972; p. 541.
2. Olzak, S.; Uhrig, S.C.N. The Ecology of Tactical Overlap. *American Sociological Review* **2001**, *66*, 694–717. [CrossRef]
3. Angerer, M.-L. *Ecology of Affect*; Meson Press: Lüneberg, Germany, 2017.
4. Keohane, N.O.; Zeckhauser, R.J. The Ecology of Terror Defense. *J. Risk Uncertain.* **2003**, *26*, 201–229. [CrossRef]
5. Biology Dictionary. Available online: https://biologydictionary.net/ecology/ (accessed on 26 March 2019).
6. Mettke-Hofmann, C. Cognitive ecology: Ecological factors, life-styles and cognition. *WIREs Cogn. Sci.* **2014**, *5*, 345–360. [CrossRef]
7. Bateson, G.; Jackson, D.D.; Haley, J.; Weakland, J.H. Towards a Theory of Schizophrenia. *Behav. Sci.* **1956**, *1*, 4, reprinted in *Steps to an Ecology of Mind*; University of Chicago Press: Chicago, IL, USA, 1972; pp. 201–227. [CrossRef]
8. Odling-Smee, F.J.; Laland, K.N.; Feldman, M.W. *Niche Construction. The Neglected Process in Evolution*; Princeton University Press: Princeton, NJ, USA, 2003.
9. Levins, R.; Lewontin, R. *The Dialectical Biologist*; Harvard University Press: Cambridge, MA, USA, 1985.
10. Goldschmidt, T. *Darwin's Dreampond. Drama in Lake Victoria*; MIT Press: Cambridge, MA, USA, 1998.
11. Varela, F.; Maturana, H. *Autopoiesis and Cognition: The Realization of the Living*; Boston Series in Philosophy of Science; D. Reidel Publishing Company: Dordrecht, Holland, 1980.
12. Varela, F. *The Principles of Biological Autonomy*; Elsevier North-Holland: New York, NY, USA, 1979.
13. Tomasello, M. *The Cultural Origins of Human Cognition*; Harvard University Press: Cambridge, MA, USA, 1999; pp. 175–178.
14. Carter, C.S.; Lederhendler, I.I.; Kirkpatric, B. *The Intergrative Neurobiology of Affiliation*; MIT Press: Cambridge, MA, USA, 1999.
15. Vytgotsky, L. *Thought and Language*; Originally published in 1934; MIT Press: Cambridge, MA, USA, 1986.

16. Dumouchel, P.; Damiano, L. Mind, Emotions and Artificial Empathy. In *Living with Robots*; Harvard University Press: Cambridge, MA, USA, 2017; pp. 96–101.
17. Hrdy, S.B. *Mothers and Others*; Harvard University Press: Cambridge, MA, USA, 2009.
18. Chapais, B. *Primeval Kinship*; Harvard University Press: Cambridge, MA, USA, 2008.
19. Camazine, S.; Deneubourg, J.-L.; Franks, N.R.; Sneyd, J.; Theraulaz, G.; Bonabeau, E. *Self-Organization in Biological Systems*; Princeton University Press: Princeton, NJ, USA, 2001; pp. 23–24.
20. Dumouchel, P.; Damiano, L. From Moral and Lethal Machines to Synthetic Ethics. In *Living with Robots*; Harvard University Press: Cambridge, MA, USA, 2017; pp. 170–205.
21. Damiano, L.; Dumouchel, P. Anthropomorphism in Human-Robot evolution. *Front. Psychol.* **2018**. [CrossRef] [PubMed]