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Mindless Abduction: From Animal Guesses to Artifactual Mediators

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1. Introduction

Many animals – traditionally considered 'mindless' organisms – make up a series of signs and are engaged in making, manifesting or reacting to a series of signs: through this semiotic activity – which is fundamentally *model-based* – they are at the same time engaged in "being cognitive agents" and therefore in thinking intelligently.[1] An important effect of this semiotic activity is a continuous process of 'hypothesis generation' that can be seen at the level of both instinctual behavior, as a kind of 'wired' cognition, and representation-oriented behavior, where nonlinguistic pseudothoughts drive a plastic model-based cognitive role. This activity is at the root of a variety of *abductive* performances. Another important character of the model-based cognitive activity is the externalization of artifacts that play the role of mediators in animal languageless reflexive thinking. The interplay between internal and external representations exhibits a new cognitive perspective on the mechanisms underlying the semiotic emergence of abductive processes in important areas of model-based thinking of 'mindless' organisms. A considerable part of abductive cognition occurs through an activity consisting in a kind of reification in the external environment and a subsequent re-projection and reinterpretation through new configurations of neural networks, and of their chemical processes. Anal-

[1] The term "model-based reasoning" is used to indicate the construction and manipulation of various kinds of representations, not mainly sentential and/or formal, but mental and/or related to external mediators and to the exploitation of internalized models of diagrams, pictures, etc. (cf. Magnani, 2009).

ysis of the central problems of abduction and hypothesis generation helps to address the problems of other related topics in model-based reasoning, like pseudological and reflexive thinking and the role of pseudoexplanatory guesses in plastic cognition.

2. 'Mindless' organisms and cognition

Philosophy has for a long time disregarded the ways of thinking and knowing of animals, traditionally considered 'mindless' organisms. Peircean insight regarding the role of abduction in animals was a good starting point, but only more recent results in the fields of cognitive science and ethology about animals, and of developmental psychology and cognitive archeology about humans and infants, have provided the actual intellectual awareness of the importance of the comparative studies.

Philosophy has anthropocentrically condemned itself to partial results when reflecting upon human cognition because it has lacked in appreciation of the more 'animal-like' aspects of thinking and feeling, which are certainly in operation and are greatly important in human behavior. Also in ethical inquiry a better understanding of animal cognition could in turn increase knowledge about some hidden aspects of human behavior, which I think still evade any ethical account and awareness.

In *Morality in a Technological World* (Magnani, 2007a), I maintain that people have to learn to be 'respected' as things sometimes are. Various kinds of 'things', and among them work of arts, institutions, symbols, and of course animals, are now endowed with intrinsic moral worth. Animals are certainly morally respected in many ways in our technological societies, but certain knowledge about them has been disregarded. It is still difficult to acknowledge respect for their cognitive skills and endowments. Would our having more knowledge about animals happen to coincide with having more knowledge about humans and infants, and be linked to the suppression of constitutive 'anthropomorphism' in treating and studying them that we have inherited through tradition? Consequently, would not novel and unexpected achievements in this field be a fresh chance to grant new 'values' to humans and discover new knowledge regarding their cognitive features? (Gruen, 2002). Darwin has already noted that studying cognitive capacities in humans and non-humans animals "possesses, also, some independent interest, as an attempt to see how far the study of the lower animals throws light on one of the highest psychical faculties of man" – the moral sense (Darwin, 1981).

Among scientists it is of course Darwin who first clearly captured the idea of an "inner life" (the "world of perception" included) in some humble earthworms. A kind of mental life can be hypothesized in many organisms: Darwin wanted "to learn how far the worms acted consciously and how much mental power they displayed" (Darwin, 1985). He found levels of "mind " where it was not presumed to exist. It can be said that this new idea, which bridges the gap between humans and other animals, in some sense furnishes a scientific support to that metaphysical synechism claimed by Peirce contending that matter and mind are intertwined and in some sense indistinguishable.[2]

2.1 Worm intelligence, abductive chickens, instincts

Let us consider the behavior of very simple creatures. Earthworms plug the opening of their burrow with leaves and petioles: Darwin recognized that behavior as being too regular to be random and at the same time too variable to be merely instinctive. He concluded that, even if the worms were innately inclined to construct protective basket structures, they also had a capacity to "judge" based on their tactile sense and showed "some degree of intelligence". Instinct alone would not explain how worms actually handle leaves to be put into the burrow. This behavior seemed more similar to their "having acquired the habit" (Darwin, 1985). Crist says: "Darwin realized that 'worm intelligence' would be an oxymoron for skeptics and even from a commonsense viewpoint 'This will strike everyone as very improbable' he wrote (Darwin, 1985). [...] He noted that little is known about the nervous system of 'lower animals', implying they might possess more cognitive potential than generally assumed" (Crist, 2002).

It is important to note that Darwin also paid great attention to those external structures built by worms and engineered for utility, comfort, and security. I will describe later on in this article the cognitive role of artifacts in both human and non-human animals: artifacts can be illustrated as *cognitive mediators* (Magnani, 2001) which are the building blocks that bring into existence what it is now called a "cognitive niche":[3] Darwin maintains that "We thus see that burrows are not mere excavations, but may rather be compared with tunnels lined with cement" (Darwin, 1985). Like

[2] The recent discovery of the cognitive roles (basically in the case of learning and memory) played by spinal cord further supports this conviction that mind is extended and distributed and that it can also be – so to say – "brainless" (Grau, 2002).

[3] A concept introduced by Tooby and DeVore (1987) and later on reused by Pinker (1997, 2003).

humans, worms build external artifacts endowed with precise roles and functions, which strongly affect their lives in various ways, and of course their opportunity to 'know' the environment.

I have said their behavior cannot be accounted for in merely instinctual terms. Indeed, the "variability" of their behavior is for example illustrated by the precautionary capacity of worms to exploit pine needles by bending over pointed ends: "Had this not effectually been done, the sharp points could have prevented the retreat of the worms into their burrows; and these structures would have resembled traps armed with converging points of wire rendering the ingress of an animal easy and its egress difficult or impossible" (Darwin, 1985). Cognitive *plasticity* is clearly demonstrated by the fact that Darwin detected that pine was not a native tree! If we cannot say that worms are aware like we are (consciousness is unlikely even among vertebrates), certainly we can acknowledge in this case a form of material, interactive, and embodied manifestation of awareness in the world.

Recent research has also demonstrated the existence of developmental plasticity in plants. For example developing tissues and organs "inform" the plant about their states and respond according to the signals and substrates they receive. The plant adjusts structurally and physiologically to its own development and to the habitat it happens to be in (for example a plasticity of organs in the relations between neighboring plants can be developed) (Sachs, 2002; Grime and Mackey, 2002).

In this article I am interested in improving knowledge on abduction and model-based thinking. By way of introduction let me quote the interesting Peircean passage about hypothesis selection and chickens, which touches on both ideas, showing a kind of completely language-free, model-based abduction:

> How was it that man was ever led to entertain that true theory? You cannot say that it happened by chance, because the possible theories, if not strictly innumerable, at any rate exceed a trillion – or the third power of a million; and therefore the chances are too overwhelmingly against the single true theory in the twenty or thirty thousand years during which man has been a thinking animal, ever having come into any man's head. Besides, you cannot seriously think that every little chicken, that is hatched, has to rummage through all possible theories until it lights upon the good idea of picking up something and eating it. On the contrary, you think the chicken has an innate idea of doing this; that is to say, that it can think of this, but has no faculty of thinking anything else. The chicken you say pecks by instinct. But if you are

> going to think every poor chicken endowed with an innate tendency toward a positive truth, why should you think that to man alone this gift is denied? CP 5.591 [1903]

and again, even more clearly, in another related passage

> When a chicken first emerges from the shell, it does not try fifty random ways of appeasing its hunger, but within five minutes is picking up food, choosing as it picks, and picking what it aims to pick. That is not reasoning, because it is not done deliberately; but in every respect but that, it is just like abductive inference. MS [1901][4]

From this Peircean perspective hypothesis generation is a largely instinctual and *nonlinguistic* endowment of human beings and, of course, also of animals.[5] It is clear that for Peirce abduction is rooted in the instinct and that many basically instinctual-rooted cognitive performances, like emotions, provide examples of abduction available to both human and non-human animals. Also cognitive archeology (Mithen, 1996; Donald, 2001) acknowledges that it was not language that made cognition possible: rather it rendered possible the integration in social environments of preexistent, separated, domain-specific modules in prelinguistic hominids, like complex motor skills learnt by imitation or created independently for the first time (Bermúdez, 2003). This integration made the emergence of tool making possible through the process of "disembodiment of mind" that I recently illustrated in (Magnani, 2006). Integration also seeks out established policies, rituals, and complicated forms of social cognition, which are related to the other forms of prevalently nonlinguistic cognitive behaviors.

[4] See the article "The proper treatment of hypotheses: a preliminary chapter, toward and examination of Hume's argument against miracles, in its logic and in its history" (MS 692 [1901]).

[5] It can be hypothesized that some language-free, more or less stable, *representational* states that are merely model-based are present in animals, early hominids, and human infants. Of course tropistic and classically conditioned schemes can be accounted for without reference to these kinds of model-based "representations", because in these cases the response is invariant once the creature in question has registered the relevant stimuli. The problem of attributing to those beings strictly nonlinguistic model-based inner "thoughts", beliefs, and desires, and thus suitable ways of representing the world, and of comparing them to language-oriented mixed (both model-based and sentential) representations, typical of modern adult humans, appears to be fundamental to comprehending the status of animal presumptive abductive performances. The problem of nonlinguistic endowments of human beings and animals is strictly related to the relationship between iconicity and logicality in reasoning and to the contrast between the instinct and heuristic strategies, I have treated in detail in the first two sections of chapter five of my recent book (Magnani, 2009).

2.2 Nonlinguistic representational states

It can be hypothesized that some language-free, more or less stable, *representational* states that are merely model-based[6] are present in animals, early hominids, and human infants. Of course tropistic and classically conditioned schemes can be accounted for without reference to these kinds of model-based 'representations', because in these cases the response is invariant once the creature in question has registered the relevant stimuli.

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Of course this issue recalls the traditional epistemological Kuhnian question of the incommensurability of meaning (Kuhn, 1962). In this case it refers to the possibility of comparing cognitive attitudes in different biological species, which express potentially incomparable meanings. Such problems already arose when dealing with the interpretation of primitive culture. If we admit, together with some ethologists, animal behaviorists, and developmental psychologists, that in nonlinguistic organisms there are some intermediate representations, it is still difficult to make an analogy with those found in adult humans. The anthropologists who carried out the first structured research on human primitive cultures and languages already stressed this point, because it is difficult to circumstantiate thoughts that can hold in beings but only manifest themselves in superficial and external conducts (cf. Quine, 1960).

A similar puzzling incommensurability already arises when we deal with the different sensorial modalities of certain species and their ways of being and of feeling to be in the world. We cannot put ourselves in the living situation of a dolphin, which lives and feels by using echolocations, or of our cat, which 'sees' differently, and it is difficult to put forward scientific hypotheses on these features using human-biased language, perceptive capacities, and cognitive representations.[7] The problem of the existence of 'representation states' is deeply epistemological: the analogous

[6] They do not have to be taken like, for example, visual and spatial imagery or other internal model-based states typical of modern adult humans, but more like action-related representations and thus intrinsically intertwined with perception and kinesthetic abilities. Saidel (2002) interestingly studies the role of these kinds of representations in rats.

[7] On this subject cf. also the classical (Nagel, 1974).

situation in science concerns for example the status of the so-called theoretical terms, like quarks or electrons, which are not directly observable but still 'real', reliable, and consistent when meaningfully legitimated/justified by their epistemological unavoidability in suitable scientific research programs (Lakatos, 1970).

I have already said that commitment to research on animal cognition is rare in human beings. Unfortunately, even when interested in animal cognition, human adult researchers, victims of an uncontrolled, 'biocentric' anthropomorphic attitude, always risk attributing to animals (and of course infants) their own concepts and thus misunderstanding their specific cognitive skills (Rivas and Burghardt, 2002).

3. Animal abduction

3.1 "Wired cognition" and pseudothoughts

Nature writes programs for cognitive behavior in many ways. In certain cases these programs draw on cognitive functions and sometimes they do not. In the latter case the fact that we describe the behavioral effect as 'cognitive' is just a metaphor. This is a case of *instinctual* behavior, which we should more properly name 'wired cognition' (or hard-wired cognition).

Peirce spoke – already over a century ago – of a wide semiotic perspective, which taught us that a human internal representational medium is not necessarily structured like a language. In this article I plan to develop and broaden this perspective. Of course this conviction strongly diverges from that maintained by the intellectual traditions which resort to the insight provided by the modern Fregean logical perspective, in which thoughts are just considered the "senses of sentences". Recent views on cognition are still influenced by this narrow logical perspective, and further stress the importance of an isomorphism between thoughts and language sentences (cf. for example Fodor's theory (Fodor, 1987)).

Bermúdez clearly explains how this perspective also affected the so-called *minimalist view* on animal cognition (also called *deflationary view*) (Bermúdez, 2003). We can describe nonlinguistic creatures as thinkers and capable of goal-directed actions, but we need to avoid assigning to them the type of thinking common to linguistic creatures, for example in terms of belief-desire psychology: "Nonlinguistic thinking does not involve propositional attitudes – and, a fortiori, psychological explanation at the nonlinguistic level is not a variant of belief-desire psychology" (ibid.). Belief-

desire framework should only be related to linguistic creatures. Instead, the problem for the researcher on animal cognition would be to detect how a kind of what we can call "general belief" is formed, rather than concentrating on its content, as we would in the light of human linguistic tools.

Many forms of thinking, such as imagistic, empathetic, trial and error, and analogical reasoning, and cognitive activities performed through complex bodily skills, appear to be basically model-based and manipulative. They are usually described in terms of living beings that adjust themselves to the environment rather than in terms of beings that acquire information from the environment. In this sense these kinds of thinking would produce responses that do not seem to involve sentential aspects but rather merely "non-inferential" ways of cognition. If we adopt the semiotic perspective above, which does not reduce the term "inference" to its sentential level, but which includes the whole arena of sign activity – in the light of Peircean tradition – these kinds of thinking promptly appear full, inferential forms of thought. Let me recall that Peirce stated that all thinking is in signs, and signs can be icons, indices, or symbols, and, moreover, all *inference* is a form of sign activity, where the word sign includes "feeling, image, conception, and other representation" (CP 5.283).

From this perspective human and the most part of non-human animals possess what I have called *semiotic brains* (Magnani, 2007b), which make up a series of signs and which are engaged in making or manifesting or reacting to a series of signs: through this semiotic activity they are at the same time occasionally engaged in 'being cognitive agents' (like in the case of human beings) or at least in thinking intelligently. For example, spatial imaging and analogies based on perceiving similarities – fundamentally context-dependent and circumstantiated – are ways of thinking in which the 'sign activity' is of a nonlinguistic sort, and it is founded on various kinds of implicit naïve physical, biological, psychological, social, etc., forms of intelligibility. In scientific experimentation on prelinguistic infants a common result is the detection of completely language-free working ontologies, which only later on, during cognitive development, will become intertwined with the effect of language and other 'symbolic' ways of thinking.

With the aim of describing the kinds of representations which would be at work in these nonlinguistic cognitive processes Dummett (1993) proposes the term *protothought*. I would prefer to use the term *pseudothought*, to minimize the hierarchical effect that – ethnocentrically – already affected some aspects of the seminal work on primitives of an author like Lévi-

Bruhl (1923). An example of the function of model-based pseudothoughts can be hypothesized in the perception of space in the case of both human and non-human animals. The perceived space is not necessarily three-dimensional and merely involves the apprehension of movement changes, and the rough properties of material objects. Dummett (1993) illustrates the case of the car driver and of the canoeist:

> A car driver or canoeist may have to estimate the speed and direction of oncoming cars and boats and their probable trajectory, consider what avoiding action to take, and so on: it is natural to say that he is highly concentrated in thought. But the vehicle of such thoughts is certainly not language: it would be said, I think, to consist in visual imagination superimposed on the visual perceived scene. It is not just that these thoughts are not in fact framed in words: it is that they do not have the structure of verbally expressed thoughts. But they deserve the name of "protothoughts" because while it would be ponderous to speak of truth or falsity in application to them, they are intrinsically connected with the possibility of their being mistaken: judgment, in a non-technical sense, is just what the driver and the canoeist need to exercise. Dummett, 1993, p. 122

3.2. Plastic cognition in organisms' pseudoexplanatory guesses

To better understand what the study of nonlinguistic creatures teaches us about model-based and manipulative abduction (and go beyond Peirce's insights on chickens' 'wired' *abductive* abilities), it is necessary to acknowledge the fact that it is difficult to attribute many of their thinking performances to innate releasing processes, trial and error or to a mere reinforcement learning, which do not involve complicated and more stable internal representations.

Fleeting and evanescent (not merely reflex-based) pseudorepresentations are needed to account for many animal 'communication' performances even at the level of the calls of "the humble and much-maligned chicken", like Evans says:

> We conclude that chicken calls produce effects by evoking representations of a class of eliciting events [food, predators, and presence of the appropriate receiver]. This finding should contribute to resolution of the debate about the meaning of referential signals. We can now confidently reject reflexive models, those that postulate only behavioral referents, and those that view referential signals as imperative. The humble and much maligned chicken thus has a remarkably sophisticated system. Its calls denote at least three classes of external objects.

> They are not involuntary exclamations, but are produced under particular social circumstances. Evans, 2002

In sum, in nonlinguistics animals, a higher degree of abductive abilities has to be acknowledged: chicken form separate representations faced with different events and they are affected by prior experience (of food, for example). They are mainly due to internally developed plastic capacities to react to the environment, and can be thought of as the fruit of learning. In general this plasticity is often accompanied by the suitable reification of external artificial 'pseudorepresentations' (for example landmarks, alarm calls, urine-marks and roars, etc.) which artificially modify the environment, and/or by the referral to externalities already endowed with delegated cognitive values, made by the animals themselves or provided by humans.

The following is an example of not merely reflex-based cognition and it is fruit of plasticity: a mouse in a research lab perceives not simply the lever but the fact that the action on it affords the chance of having food; the mouse 'desires' the goal (food) and consequently acts in the appropriate way. This is not the fruit of innate and instinctual mechanisms, merely a trial and error routine, or brute reinforcement learning able to provide the correct (and direct) abductive appraisal of the given environmental situation. Instead it can be better described as the fruit of learnt and flexible *thinking* devices, which are not merely fixed and stimulus driven but also involve 'thought'. 'Pseudothought' – I have already said – is a better term to use, resorting to the formation of internal structured representations and various – possibly new – links between them. The mouse also takes advantage in its environment of an external device, the lever, which the humans have endowed with a fundamental predominant cognitive value, which can afford the animal: the mouse is able to cognitively pick up this externality, and to embody it in internal, useful representations.

Another example of plastic cognition comes from the animal activity of reshaping the environment through its mapping by means of seed caches:

> Consider, for example, a bird returning to a stored cache of seeds. It is known from both ethological studies and laboratory experiments that species such as chickadees and marsh tits are capable of hiding extraordinary number of seeds in a range of different hiding places and then retrieving them after considerable periods of time have elapsed. Sherry, 1988 (quoted in Bermúdez, 2003)

It is also likely to hypothesize that this behavior is governed by the combination of a motivational state (a general desire for food) and a memory of

the particular location, and how to get to it.[8] The possibility of performing such behavior is based on structured internal pseudorepresentations originating from the previous interplay between internal and external signs suitably picked up from the environment in a step-by-step procedure.

To summarize, in these cases we are no longer observing the simple situation of the Peircean, picking chicken, which "has an innate idea of doing this; that is to say, that it can think of this, but has no faculty of thinking anything else". This "cognitive" behavior is the one already described by the minimalist contention that there is no need to specify any kind of internal content. It is minimally – here and now and immediately related to action – goal-directed, mechanistic, and not "psychological" in any sense, even in a metaphorical one, as we use the term in the case of animals (Bermúdez, 2003).

On the contrary, the birds in the example above have at their disposal flexible ways of reacting to events and evidence, which are explainable only in terms of a kind of thinking 'something else', to use the Peircean words, beyond mere mechanistic pre-wired responses. They can choose between alternative behaviors founding their choice on the basis of evidence available to be picked up. The activity is 'abductive' in itself: it can be *selective*, when the pseudoexplanatory guess, on which the subsequent action is based, is selected among those already internally available, but it can also be *creative*, because the animal can form and excogitate for the first time a particular pseudoexplanation of the situation at hand and then creatively act on the basis of it. The tamarins quickly learn to select the best hypothesis about the tool – taking into account the different tools on offer – that has to be used to obtain the most food in 'varied' situations. To avoid 'psychological' descriptions, animal abductive cognitive reaction at this level can be seen as an emergent property of the whole organism, and not, in an anthropocentric way, as a small set of specialized skills like we usually see them in the case of humans. By the way, if we adopt this perspective it is also easier to think that some organisms can learn and memorize even without the brain.[9]

Animals occupy different environmental niches that "directly" afford their possibility to act, like Gibson's original theory teaches, but this is

[8] Of course the use of concepts like 'desire', deriving from the 'folk-psychology' lexicon, has to be considered merely metaphorical.

[9] It is interesting to note that recent neurobiological research has shown that neural systems within the spinal cord in rats are quite a bit smarter than most researchers have assumed, they can, for example, learn from experience (Grau, 2002). Cf. also footnote 2 above.

only one of the ways the organism exploits its surroundings to be suitably attuned to the environment. When behaviors are more complicated other factors are at stake. For example, animals can act on a goal that they cannot perceive – the predator that waits for the prey for example – so the organism's appraisal of the situation includes factors that cannot be immediately perceived.

Well-known dishabituation experiments have shown how infants use model-based high-level physical principles to relate to the environment. They look longer at the facts that they find surprising, showing what expectations they have; animals like dolphins respond to structured complex gestural signs in ways that can hardly be accounted for in terms of the Gibsonian original notion of immediate affordance. A similar situation can be seen in the case of monkeys that perform complicated technical manipulations of objects, and in birds that build artifacts to house beings that have not yet been born. The problem here is that organisms can dynamically abductively 'extract' or 'create' – and further stabilize – affordances not previously available, taking advantage not only of their instinctual capacities but also of the plastic cognitive ones.[10]

4. Conclusion

The main thesis of this paper is that model-based reasoning represents a significant cognitive perspective able to unveil some basic features of abductive cognition in non-human animals. Its fertility in explaining how animals make up a series of signs and are engaged in making or manifesting or reacting to a series of signs in instinctual or plastic ways is evident. Indeed in this article I have demonstrated that a considerable part of this semiotic activity is a continuous process of hypothesis generation that can be seen at the level of both instinctual behavior and representation-oriented behavior, where nonlinguistic pseudothoughts drive a 'plastic' model-based cognitive role. I also maintain that the various aspects of these abductive performances can also be better understood by taking some considerations on the concept of affordance into account. From this perspective the referral to the central role of the externalization of artifacts that act as mediators in animal languageless cognition becomes critical to the problem of abduction. Moreover, I tried to illustrate how the interplay between internal and external 'pseudorepresentations' exhibits a new cog-

[10] On the creation/extraction of new affordances through both evolutionary changes and construction of new knowledge and artifacts cf. Magnani and Bardone (2007).

nitive perspective on the mechanisms underling the emergence of abductive processes in important areas of model-based inferences in the so-called mindless organisms.[11]

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[11] Other aspects concerning the relationships between animal cognition and abduction are treated in Magnani (2007c).

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