Is Instinct Rational? Are Animals Intelligent?
An Abductive Account

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Abstract

The concept of abduction can be useful to clarify the conflict instinct vs. inference in cognitive science. The resulting idea that abduction is partly explicable as a biological instinctual phenomenon and partly as a more or less "logical" operation related to "plastic" cognitive endowments of all organisms naturally leads to stress that 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 considerably model-based – they are at the same time engaged in "being cognitive agents" and therefore in thinking intelligently. 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 "hardwired" cognition, and representation-oriented behavior, where nonlinguistic pseudothoughts drive a plastic model-based cognitive role. Another important character of the abductive model-based cognitive activity above is the externalization of artifacts that play the role of mediators in animal languageless "thinking". That is, 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.

Keywords: Abduction; instinct; rationality; animal cognition.

Instinct vs. Inference

The concept of abduction (Magnani, 2009) can be useful to clarify the conflict instinct vs. inference in cognitive science. We can overcome this conflict simply by observing that the work of abduction is partly explicable as a biological phenomenon and partly as a more or less "logical" operation related to "plastic" cognitive endowments of all organisms. I entirely agree with Peirce: a guess in science and the appearance of a new hypothesis is also a biological phenomenon and as such it is related to instinct, in the sense that we can compare it to a chance variation in biological evolution (even if of course the evolution of scientific guesses does not conform to the pattern of biological evolution). An abduced hypothesis introduces a change (and an opportunity) in the semiotic processes to advance new perspectives in the coevolution of the organism and the environment (gene/cognive niches coevolution (Odling-Smee, Laland, & Feldman, 2003)).

The resulting idea that abduction is partly explicable as a biological instinctual phenomenon and partly as a more or less "logical" operation related to "plastic" cognitive endowments of all organisms naturally leads to stress that 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.[1] Through this semiotic activity – which is considerably model-based[2] – they are at the same time engaged in "being cognitive agents" and therefore in thinking intelligently. 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 "hardwired" 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 human and nonhuman abductive performances, which I have also analyzed in the light of the concept of affordance (Magnani, 2009, chapter five). Another important character of the model-based cognitive activity above is the externalization of artifacts that play the role of mediators in animal languageless "thinking".[3] That is, 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 followed by re-projection and reinterpretation through new configurations of neural networks and their chemical processes. I contend that the analysis of the central problems of abduction and hypothesis generation can help to address the problems of other related topics in model-based animal cognition, like pseudological and reflexive thinking, the role of pseudoexplanatory guesses in plastic cognition, the role of reification and beliefs and the problem of the relationship between abduction and perception, and between rationality and instincts.

Rationality of Instincts

Instincts are usually considered irrational or at least a-rational. Nevertheless, there is a way of considering the behavior performances based on them as *rational*. Based on this conclusion, while all animal behavior is certainly described as

[1] For a recent survey on the current research on the origin, evolution, dynamics, and learning of signaling systems, in humans and other animals, both from an individual and a "network" perspective, cf. (Skyrms, 2008).

[2] I strongly maintain (Magnani, 2002, 2009) that there are two kinds of abduction, "sentential", related to logic and to verbal/symbolic inferences, and "model-based", related to the exploitation of internalized (or to the manipulation of external) models of diagrams, pictures, etc., cf. below in this paper. I have to note that the idea of extension of the notion of abduction beyond logic is sometimes disputed in the cognitive science literature.

[3] On the common historical view – defended, for example by Daniel Dennett, Michael Dummett, and Donald Davidson, has been that we should not assign rich cognitive abilities to creatures that lack language, cf. (Francescotti, 2007).

rational, at the same time it is still rudimentarily considered instinctual. The consequence is that every detailed hypothesis on animal intelligence and cognitive capacities is given up: it is just sufficient to acknowledge the general rationality of animal behavior. Let us illustrate in which sense we have to interpret this apparent paradox. I think the analysis of this puzzling problem can further improve knowledge about model-based and manipulative ways of thinking in humans, offering at the same time an integrated view regarding some central aspects of organisms' cognitive behavior. Furthermore, I contend that the argument for reduction of the distinction between abductive inference and perception/instinct offers the suitable philosophical/cognitive tools to make up this integrated view.

Explanations in terms of psychological states obviously attribute to human beings propositional attitudes, which are a precondition for giving a *rational* picture of the explained behavior. These attitudes are a combination of beliefs and desires. Rational internal – doxastic – states characterize human behavior and are related to the fact that they explain why a certain behavior is appropriate on the basis of a specific relationship between beliefs, desires, and actions (cf. (Magnani, 2007b, chapter seven)). How can this idea of rationality be extended to nonlinguistic creatures such as human infants and several types of animals, where the role of instinct is conspicuous? How can the inferential transformations of their possible internal "thoughts" be recognized when, even if conceivable as acting in their nervous systems, these thoughts do not possess linguistic/propositional features?

The whole idea of rationality in human beings is basically related to the fact we are able to apply *deductive* formal-syntactic rules to linguistic units in a truth preserving way, an image that directly comes from the tradition of classical logic: a kind of rationality robustly related to "logico-epistemological" ideals. The computational revolution of the last decades has stressed the fact that rationality can also be viewed as linked to ways of thinking such as *abduction* and *induction*, which can in turn be expressed through more or less simple *heuristics*. These heuristics are usually well-assessed and shared among a wide community from the point of view of the criteria of applicability, but almost always they prove to be strongly connected in their instantiation to the centrality of language. Indeed cognitive science and epistemology have recently acknowledged the importance of model-based and manipulative ways of rational thinking in human cognition, but their efficacy is basically considered to be strictly related to their hybridization with the linguistic/propositional level. Consequently, for the reasons I have just illustrated, it is still difficult to acknowledge the rationality of cognitive activities that are merely model-based and manipulative, like those of animals.

At the beginning of this section I said that, when dealing with rationality in nonlinguistic creatures, tradition initially leads us to a straightforward acknowledgment of the presumptive and intrinsic rationality of their instincts. The background assumption is the seeming impossibility that something ineluctable like instinct cannot be at the same time intrinsically rational. Of course the concept of rationality is in this case paradoxical and the expression rationality has to be taken in a Pickwickian sense: indeed, in this case the organisms at stake "cannot" be irrational. A strange idea of rationality! Given the fact that many performances of nonlinguistic organisms are explainable in terms of sensory preconditioning (and so are most probably instinct-based – hardwired – and without learnt and possibly conscious capacities which enable them to choose and decide), the rationality of costs and benefits in these behaviors is expressed in the "non-formal" terms of Darwinian "fitness". For example, in the optimal foraging theory, rationality is related to the animal's capacity – hardwired thanks to evolution – to optimize the net amount of energy in a given interval of time. Contrarily to the use of some consciously exploited heuristics in humans, in animals many heuristics of the same kind are simply hardwired and so related to the instinctual adaptation to their niches.

The following example provided by Bermúdez can further clarify the problem. "Redshanks are shorebirds that dig for worms in estuaries at low tide. It has been noticed that they sometimes feed exclusively on large worms and at other times feed on both large and small worms. [...] In essence, although a large worm is worth more to the red shank in terms of quantity of energy gained per unit of foraging time than a small worm, the costs of searching exclusively for large worms can have deleterious consequences, except when the large worms are relatively plentiful" (Bermúdez, 2003, p. 117). The conclusion is simple: even if the optimal behavior can be described in terms of a rational complicated version of expected utility theory, "[...] the behaviors in which it manifests itself do not result from the application of such a theory" (*ibid*.). We can account for this situation in abductive terms: the alternatives which are "abductively" chosen by the redshanks are already wired, so that they follow hardwired algorithms developed through evolution, and simply instantiate the idea of abduction related to instincts present in Peircean insights: "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".[4]

The situation does not change in the case that we consider short-term and long-term rationality in evolutionary behaviors. In the case of the redshank we deal with "short-term" instinct–based rationality related to fitness, but in the case of animals that sacrifice their lives in a way that increases the lifetime fitness of other individuals we deal with "long-term" fitness. It has to be said that sometimes animals are also "hardwired" to use external landmarks and territory signs,

[4]Cf. 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" [1901], in (Peirce, 1966, p. 692).

and communicate with each other using these threat-display signals that consent them to avoid direct conflict over food. These artifacts are just a kind of instinct-based *mediators*, which are "instinctually" externalized and already evolutionarily stabilized. These mediators are similar to the cognitive, epistemic, and moral mediators that humans externalize thanks to their plastic high-level cognitive capacities, but less complex and merely instinct-based.[5]

Levels of Rationality in Animals

Beyond the above idea of rationality in animals and infants as being related to tropistic behaviors connected to reflexes and inborn skills such as imprinting or classical conditioning, the role of intermediary internal representations has to be clearly acknowledged. In this last case we can guess that a rational intelligence closer to the one expressed in human cognition, and so related to higher levels of abductive behavior, is operating. We fundamentally deal with behaviors that show the capacity to choose among different outcomes, and which can only be accounted for by hypothesizing learnt intermediate representations and processes. In some cases a kind of decision-making strategy can also be hypothesized: in front of a predator an animal can fight or flee and in some sense one choice can be more rational than the other. In front of the data, to be intended here as the "affordances" in a Gibsonian sense, provided through mere perception and which present various possibilities for action, a high-level process of decision-making is not needed, but choice is still possible. With respect to mere pre-wired capacities the abductive behavior above seems based on reactions that are more flexible.

(Bermúdez, 2003, p. 121) labels Level 1 this kind of rationality. It differs from rationality intended as merely instinct-based, expressed in immutable rigid behaviors (called Level 0). Level 1 rationality (which can still be split in short-term and long-term) is for example widespread in the case of animals that entertain interanimal interactions. This kind of rationality would hold when we clearly see ir-rational animals, which fail to signal to the predator and instead flee, thus creating a bad outcome for group fitness (and for their own lifetime fitness: other individuals will cooperate with them less in the future and it will be less probable for them to find a mate).

To have an even higher level rationality (Level 2) we need to involve the possibility of abductively selecting among different hypotheses which make the organisms able to perform certain behaviors: a kind of capacity to select among different hypotheses about the data at hand, and to behave correspondingly. This different kind of rational behavior, is neither merely related to instincts nor simply and rudimentarily flexible, like in the two previous cases.

To make the hypothesis regarding the existence of this last form of rationality plausible, two epistemological preconditions have to be fulfilled. The first is related to the acknowledgment that model-based and manipulative cognitions are endowed with an "inferential" status in the Peicean wide semiotic sense of the word Peirce: all inference is a form of sign activity, where the word sign includes "feeling, image, conception, and other representation" (Peirce, 1931-1958, 5.283).

The second relates to the rejection of the restricted logical perspective on inference and rationality I have described in the previous section, which identifies inferences at the syntactic level of natural and artificial/symbolic languages (in this last case, also endowed with the truth-preserving property, which produces the well-known isomorphism between syntactic and semantic/content level). I think the perspective in terms of multimodal abductive cognition,[6] which avoids old-fashioned models of rationality, furnishes the suitable background for a unified analysis of the issue.

At this high-rationality level we can hypothesize in nonlinguistic organisms more than the simple selection of actions, seen as merely hardwired and operating at the level of perceptions like the theory of immediate affordances teaches, where a simple instrumental conditioning has attached to some actions a positive worth. Instead, in Level 2 rationality, complicated, relatively stable, internal representations that account for consequences are at work. In this case selecting is selecting – so to speak – for some "reasons": a bird that learns to press a lever in a suitable way to obtain food, which will then be delivered in a given site, acts by considering an association between that behavior and the consequences. A kind of instrumental pseudobelief about the future and about certain probable regularities is established, and contingencies at stake are represented and generalized in a merely model-based way. Then the organism internally holds representations with some stability and attaches utility scores to them: based on their choice a consequent action is triggered, which will likely satisfy the organism's desire. The action will be stopped, in a nonmonotonic way, only in the presence of outcoming obstacles, such as the presence of a predator.

Of course the description above suffers the typical anthropomorphism of the observer's "psychological" explanations. However, beliefs do not have to be considered explicit; nevertheless, some actions cannot be explained only on the basis of sensory input and from knowledge of the environmental parameters. Psychological explanations can be highly plausible when the goal of the action is immediately perceptible or when the distal environment contains immediately perceptible instrumental properties. This is obvious and evident in the case of human beings' abilities, but something similar occurs in some chimpanzees' behavior too. When chimpanzees clearly see some bananas they want to reach and eat, and

[5] I have fully described the role of epistemic mediators in scientific reasoning in chapter one of my book (Magnani, 2009), and of moral mediators in ethics in (Magnani, 2007b).

[6] From the perspective of distributed cognition I also stress that abduction is essentially *multimodal*, in that both data and hypotheses can have a full range of verbal and sensory representations, involving words, sights, images, smells, etc., but also kinesthetic – related to the ability to sense the position and location and orientation and movement of the body and its parts – and motor experiences and other feelings such as pain, and thus all sensory modalities (Magnani, 2009, chapter four).

some boxes available on the scene, they have to form an internal instrumental belief/representation on how to exploit the boxes. This "pseudobelief" is internal because it is not immediately graspable through mere perceptual content:

> Any psychological explanation will always have an instrumental content, but the component needs not take the form of an instrumental belief. [...] instrumental beliefs really only enter the picture when two conditions are met. The first is that the goal of the action should not be immediately perceptible and the second is that there should be no immediately perceptible instrumental properties (that is to say, the creature should be capable of seeing that a certain course of action will lead to a desired result). The fact, however, that one or both of these conditions is not met does not entail that we are dealing with an action that is explicable in non-psychological terms (Bermúdez, 2003, p. 129).

The outcomes are represented, but these "pseudorepresentations" lack in lower kinds of rationality. The following example is striking. A food source was taken away from chicken at twice the rate they walked toward it but advanced toward them at twice the rate they walked away from it: after 100 trials, this did not affect the creatures' behavior which failed to represent the two contingencies ((Hershberger, 1986) quoted in (Bermúdez, 2003, p. 125)). Chicken, which do not retreat from a certain kind of action faced with the fact that a repeated contingency no longer holds, are not endowed with this high level "pseudorepresentational" kind of abductive rationality.

The widespread diffusion of abductive cognition is also confirmed by research into the cognitive basis of science dealing with the potential rational behavior of certain early hominids. (Carruthers, 2002, p. 78) contests the discontinuity view supporting the idea according to which the human mind needs to be radically reprogrammed by immersion in an appropriate language-community and culture to acquire cognitive processes (and "in order for anything resembling science to become possible"). The evolutionary successful, and "social", art of tracking in hunter-gatherer communities would have helped them to develop imagination – linguistic and model-based – and thus, hypothetical cognition (abductive) – endowed with a kind of explanatory, causal, and instrumental/predictive power. It would have come about because of its capacity to detect the behavior of animals through the few signs available, to reach the best explanation. This contention offers Carruthers the chance to state that "[...] anyone having a capacity for sophisticated tracking will also have the basic cognitive wherewithal to engage in science" (Carruthers, 2002, 83). The only difference lies in aims and beliefs, and of course in the fact that the development of science needed suitable props and aids, such as instruments, the printing press and a collective exchange of ideas. The human beings that created science would not have needed major cognitive reprogramming.

Artifactual Mediators and Languageless Pseudological Thinking

Animal Artifactual Mediators

Even if the animal construction of external *artifactual mediators* is sometimes related to instinct, it can also be the fruit of plastic cognitive abilities strictly related to the need to improve actions and decisions.[7] In this case action occurs through the expert delegation of cognitive roles to external tools, like in the case of chimpanzees in the wild, that construct wands for dipping into ant swarms or termite nests. These wands are not innate but highly specialized tools. They are not merely the fruit of conditioning or trial and error processes as is clearly demonstrated by the fact they depend on hole size and they are often built in advance and away from the site where they will be used.

The construction of handaxes by the hominids had similar features. It involved paleocognitive model-based and manipulative endowments such as fleeting consciousness, private speech, imposition of symmetry, understanding fracture dynamics, ability to plan ahead, and a high degree of sensorimotor control. They represent one of the main aspects of the birth of *material culture* and technical intelligence and are at the root of what it has been called the process of a "disembodiment of mind" (Magnani, 2006; Mithen, 1996).

From this perspective the construction of artifacts is an "actualization" in the external environment of various types of objects and structures endowed with a cognitive/semiotic value for the individual of for the group. Nonlinguistic beings already externalize signs like alarm calls for indicating predators and multiple cues to identify the location of the food caches, which obey the need to simplify the environment and which of course need suitable spatial memory and representations (Shettleworth, 2002; Balda & Kamil, 2002). However, animals also externalize complicated artifacts like in the case of Darwin's earthworms (Crist, 2002).[8]

[7] Also plants exhibit interesting plastic changes. In resource-rich productive habitats where the activities of the plants "generate" various resources above and below ground that strongly modify the environment, plants themselves exhibit various kinds of, so-called, morphological plasticity – that is, the replacement of existing tissues (Grime & Mackey, 2002, p. 300). It is important to note that plant plasticity is particularly advantageous when responses are reversible rather than irreversible (Alpert & Simms, 2002). On plants phenotypic plasticity, like their reaction to appropriate environmental cues, see also (Godfrey-Smith, 2002); on plants capacity to build complicated niches (plasticity in dispersal, flowering timing, and germination timing) cf. (Donohue, 2005). On animals artifacts cf. also the articles by James L. Gould (Gould, 2007) and Jean Mandler (Mandler, 2007) contained in the recent (Margolis & Laurence, 2007); the book also illustrates other interesting psychological, neurological, evolutionary, and philosophical issues concerning artifacts in general.

[8] Among scientists it is of course Darwin (Darwin, 1985) who first clearly captured the idea of an "inner life" (the "world of perception" included) in some humble earthworms (Crist, 2002). 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, p. 3). 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,

These activities of cognitive delegation to external artifacts is the fruit of expert behaviors that conform to innate or learnt embodied templates of cognitive doing. In some sense they are analogous to the templates of epistemic doing I have described in chapter one, which explain how scientists, through appropriate actions and by building artifacts, elaborate for example a simplification of the reasoning task and a redistribution of effort across time. For example, Piaget says, they "[...] need to manipulate concrete things in order to understand structures which are otherwise too abstract" (Piaget, 1974) also to enhance the social communication of results. Some templates of action and manipulation, which are implicit and embodied, can be *selected* from the set of the ones available and pre-stored, others have to be *created* for the first time to perform the most interesting creative cognitive accomplishments of manipulative cognition. Manipulative "thinking through doing" is creative in particularly skilled animals, exactly like in the case of human beings, when for example chimpanzees make a "new" kind of wand for the first time. Later on the new behavior can possibly be imitated by the group and so can become a shared "established" way of building artifacts. Indeed chimpanzees often learn about the dynamic of objects from observing them manipulated by other fellows: a process that enhances social formation and transmission of cognition.

Pseudological Thinking

Among the various ways of model-based cognition – still related to the problem of animal rationality – present in nonlinguistic organisms, some can be equated to well-known inferential functional schemes which logic has suitably framed inside abstract and ideal systems. There are forms of pseudological uses of negation (for example dealing with presence/absence, when mammals are able to discern that a thing cannot have simultaneously two contrary properties), of *modus ponens* and *modus tollens* (of course both related to the presence of a pseudonegation), and of conditionals (cf. (Bermúdez, 2003, chapter seven)). Of course, these ways of reasoning are not truth preserving operations on "propositions" and so they are not based on logical forms, but it can be hypothesized that they are very efficient at the nonlinguistic level, even if they obviously lack an explicit reference to logical concepts and schemes.[9] They are plausibly all connected with innate abilities to detect regularities in the external niche. In addition, forms of causal thinking are observed, of course endowed with an obvious survival value, related to the capacity to discriminate causal links from mere non-causal generalizations or accidental conjunctions.[10]

It is interesting to note in prelinguistic organisms the use of both logical and fallacious types of reasoning. For example the widespread use of "hasty generalization" shows that poor generalizations must not only be considered – in the perspective of a Millian abstract universal standard – as a bad kind of induction. Even if hasty generalizations are considered bad and fallacious in the light of epistemological ideals, they are often strategic to the adaptation of the organism to a specific niche (Woods, 2004; Magnani, 2007a).

Conclusion

In this paper, beyond the idea of rationality in animals and infants as being related to tropistic behaviors connected to reflexes and inborn skills such as imprinting or classical conditioning, I have stressed the role of intermediary internal representations. In this last case I have guessed that a rational intelligence closer to the one expressed in human cognition, and so related to higher levels of abductive behavior, is operating. We fundamentally deal with behaviors that show the capacity to choose among different outcomes, and which can only be accounted for by hypothesizing learnt intermediate representations and processes. The main concern was that model-based abductive cognition represents a significant unifying cognitive perspective able to unveil some basic features of abductive cognition in non-human animals. I have illustrated 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. From this perspective referral to the central role of the externalization of artifacts that act as mediators in animal languageless cognition also becomes epistemologically critical to the problem of multimodality of abduction. An open question – still related to the problem of rationality – I have not addressed in this paper is related to the problem of how nonlinguistic creatures could possess second-order thoughts on thoughts (and so the more or less rational capacity to attribute thoughts to others) and first – and second-order – desires (that is desires when one should have a specific first-order desire).

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in some sense furnishes a partial scientific support to that metaphysical synechism claimed by Peirce contending that matter and mind are intertwined and in some sense indistinguishable. 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).

[9] On the formation of idealized logical schemes in the interplay between internal and external representations cf. (Magnani, 2007a) and chapter seven of (Magnani, 2009). Further results about the role of proto-logical and illogical performances humans share (or do not share) with some animals cf. (Yamazaki, Okanoya, & Iriki, 2006).

[10] Human prelinguistic infants show surprise in front of scenes when "action-at-a-distance" is displayed (it seems they develop a pseudothought that objects can only interact causally through physical contact) (Spelke, 1990). Some fMRI experiments on "perceptual" causality are described in (Fugelsang, Roser, Corballis, Gazzaniga, & Dunbar, 2005): specific brain structures result involved in extracting casual frameworks from the world. In both children and adults these data show how they can grasp causality without inferences in terms of universality, probability, or casual powers.

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