SO LITTLE BRAIN, SO MUCH MIND
INTELLIGENCE AND BEHAVIOUR IN NON HUMAN ANIMALS
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Abstract: Cognitive scientists frequently (and implicitly) seem to assume that the more evolutionary proximity there is between an animal and Homo sapiens, the more its (brain/mind and behaviour will be similar to ours. For example, while it is very common to read scientific papers that compare non-human primate behaviours, in particular chimpanzee (Pan troglodytes and Pan paniscus), to human behaviours, it is very rare, in contrast, to read a scientific paper on human mind that refers to insect cognition data. In this paper we try to challenge this unnoticed anthropocentric (and primatecentric) bias, which prevent us to see deep similarities across the cognitive abilities of living beings. The basic idea of this paper is that a «core» cognitive system exists which is widespread among animals, including humans. What differentiates human mind from other minds is language.

Keywords: insect mind, theory of mind (ToM), language and cognition, scala naturae.

1. INTRODUCTION

There is a growing body of data that shows how complex and sophisticated are the cognitive abilities of those that till not so long time ago would have been called «lower», «inferior» or «simpler» animals. In particular there is a growing amount of evidence on the remarkable cognitive performances of insect minds (Avarguès-Weber, Giurfa 2013). Bees, for example, whose brain does not reach a million of neurons, are capable of extraordinary feats, such as discriminating and recognizing individual human faces (Dyer et al. 2005; Avarguès-Weber et al. 2009).

In an evolutionary perspective we should expect such an ability in humans, but why in bees? Differently from some species of wasps, that possess features in the head regions that allow for individual recognition (Sheehan, Tibbetts 2011), in honeybees the ability to recognize faces seems to be the by-product of more general pattern recognition mechanisms, that are used for instance during foraging (Dyer et al. 2005; Avarguès-Weber et al. 2009).
These data raise a theoretical issue: Cognitive scientists more or less implicitly assume that the more evolutionary proximity there is between an animal and *Homo sapiens*, the more its (brain/mind) and behaviour will be similar to ours. It is such a tacit assumption that could explain why so much research is conducted on primates (especially chimpanzees) cognition in comparison to other animals. We are well aware that this is somehow a rhetorical exaggeration. But while it is very common to read scientific papers that compare non-human primate behaviours, in particular chimpanzee (*Pan troglodytes* and *Pan paniscus*), to human behaviours, it is very rare, in contrast, to read a scientific paper on human mind that refers to insect cognition data. Is there any scientific or biological reason which prevents a direct match of bee mind with *Homo sapiens* mind? Since insects bodies are so different from those of human beings there is a tacit assumption that their mind would be completely different from our mind (Tye 1997). Sometimes it seems as if our research agenda was inspired by the superficial similarity between a mammal muzzle and a face. The hidden rule which seems to guide some research on comparative cognition seems to be the following one: the more external similarity, the more cognitive proximity. In fact there is no scientific rationale, for example, to prefer chimp mind to bee mind if we want to understand the biological (and, as it seems, universal) capacity to discriminate a face from a non-face. Even if we know very well that the ancient notion of *scala naturae* is scientifically nonsensical, an unconscious prejudice still exists that human beings are somehow at the top of nature, and that close there are the animals whose bodies are similar to our own. A bee body is too much different from a mammalian body, therefore its mind must be different from a typical mammalian mind, not to mention human mind. Probably this is one of the main reasons for the long skepticism about von Frisch discovery of dance language of bees (Munz 2005): it seemed impossible that such a little brain could manage to communicate symbolically. This is a very clear example of our point: research on language origins almost always refers to gestural primate communicative behaviour (e.g. Hewes 1973), which is much simpler – from a cognitive and semiotic point of view – than the honeybee dance. But if we really want to find a plausible evolutionary analogous of human language it is more likely that we can find it in the brain of a bee than in the brain of a chimp.

Insect intelligence represents a strong challenge to our biological and evolutionary prejudices: complex cognition is not an exclusive
mammal, and in particular primate, characteristic, or of birds such as corvids (see Emery and Clayton, 2004). Our point is not simply that there is much more intelligence in nature than we imagine (Aristotle, *De Anima*). The general point we want to raise is this: What is the best theoretical model to understand animal mind? That is, how many basic cognitive mechanisms we need in order to make sense of animal mind? How strong are the differences between different animal minds and, on the contrary, how close are the similarities between them? How many kinds of minds do exist in nature? In the following pages we will try to develop some of the theoretical and practical consequences of recent scientific discoveries.

2. HOW MANY KINDS OF MIND EXIST?

What are the minimal cognitive abilities that an animal needs in order to survive in nature and reproduce in a natural environment? First, a capacity to keep internal tracks of the experiences with the external world. That is, a form of memory is a necessary precondition for life. Then, an ability to discriminate stimuli and to categorize them in different classes is a widespread and crucial capacity for every living being, not only animals (Baluška et al. 2009a, 2009b). It is a capacity which does not require a brain or a central nervous system to be implemented. Strictly related to categorization is the capacity for action in the world. In fact categories serve the purpose of acting similarly to different types of stimuli that are classified together. Like the case of plant action (Baluška et al. 2009b) exemplarily shows, life would be impossible without the capacity of some form of action. It is obvious that huge differences exist in the kind of sensory capacities in animals. The same applies to the very different animal capacity to keep track of past experiences. Our point is not that all animals behave in the same way, which is evidently untenable: our point is that all animal (and vegetable) minds are based on a very simple set of basic cognitive abilities, which are more or less the same for all of them (Macphail 1993). Put in another way: animal minds share a basic cognitive software (Zentall et al. 2008) which can be implemented in very different hardwires.

Consider the case of chicken’s mind, for example. Very early in life, and with little or no previous specific experience, neonate domestic chicks show an ability to grasp basic, intuitive concepts of objects
mechanics, such as the fact that physical objects occupy a space that cannot be subtracted to them without an external action or collision (Chiandetti, Vallortigara, 2011) and are thus capable of recognizing causal agency in object-object interactions (Mascalzoni et al. 2010). Besides, chicks show basic understanding of quantity, including subtraction and addition of numerosities (Rugani et al. 2009; Vallortigara et al. 2010), they map numbers to space similar to humans (Rugani et al. 2010; Rugani et al. 2015), and conjoin Euclidian metric and sense (right-left) properties of physical surfaces to encode basic geometric properties of the physical layout (Chiandetti, Vallortigara 2008, 2010; Vallortigara et al. 2009). They also show object individuation based on spatio-temporal and kind properties (Fontanari et al. 2011, 2014), and mechanisms for animacy detection (Rosa Salva et al. 2010, 2014), which seem to be the same as those shown by newborn and human infants (Rosa Sava et al. 2011; Mascalzoni et al. 2010; Simion et al. 2008).

In short, animals whose last common ancestor with humans dates back to 280 millions ago, exhibit what Spelke (2003) dubbed «core knowledge», i.e. a set of cognitive systems for representing significant aspects of the environment, such as physical objects, living beings, spatial relationships and number. Core knowledge systems (that can be largely unlearned) would allow organisms to pay attention to stimuli, to discriminate, categorize and remember them; also, they allow organisms to act in the world according (i) to what perception has previously detected, and (ii) according to an animal’s biological needs.

Notwithstanding the very different perceptual and bodily equipment of animals, the cognitive engine is the same (what is variable is the displacement of this engine). Ceteris paribus if we compare cognitive abilities in prelinguistic children and nonlinguistic animals, we can find that the behavioural similarities are stronger than the differences: «Hence the null hypothesis – that there are no differences in intellect among nonhuman vertebrates – should be adopted; the superiority of human intelligence stems from our possessing a species-specific language-acquisition device» (Macphail 1987). What we suggest here is that such a «null hypothesis» should be extended to invertebrates too.

According to Spelke, language would have the «magic property» to make us smart: «Thanks to their compositional semantics, natural languages can expand the child’s conceptual repertoire to include not just the preexisting core knowledge concepts but also any new
well-formed combination of those concepts» (Spelke 2003). Language allows humans to form and to think to abstract non-perceptual concepts (Vygotsky 2012). It has been claimed that the apparent improvement of the cognitive ability of nonhuman animals which have been trained to use a (human made) symbolic language (Call, Tomasello 1996; Thompson et al. 2001; Premack 2004) would provide evidence for this. One objection, however, is to what extent the effect is specific (i.e. whether it depends on training on symbolic language or any sort of generic training would be effective).

Here we propose as a research agenda which assumes the existence of just two kinds of mind: nonlinguistic minds and linguistic minds (the latter not necessarily restricted to *Homo sapiens*). It is quite clear that this a very sharp dichotomy, nevertheless it has the major advantage to avoid any form (explicit or implicit, conscious or unconscious) of anthropocentrism, that is the risk to assume our mind as the reference standard in comparative animal cognition studies.

3. BEYOND THE CHIMPOCENTRISM

A living chimpanzee behaviour is not at all an example of what a primitive (not yet) *sapiens* could have been 6.5 mya (Vaesen 2014). A living chimpanzee is so much philogenetically distant from our last common ancestor as we are. If a chimp shows a particular behaviour, there is no strong reason to believe that the same behaviour was present in the last commune ancestor we share. Consider the case of human language. Chimpanzee natural communicative behaviour (Tomasello, Zuberbüler 2002) is strikingly more simple when compared to honeybees dance language (von Frisch 1967; Dyer 2002). For example, honeybees can use signals that refer to entities which are completely out of sight; that is, bees can communicate about entities which are very far in space and time. In nature chimpanzees do not show, as far as we know, a similar behaviour, that is, using a signal which refers to a far object. From this point of view a striking similarity does exist between bee communicative dance and human language: a similarity which does not imply a nervous system or brain similarity. What we would like to stress is that a biological comprehension of human mind does not necessarily imply to restrict the comparison to the animal species which are phylogenetically closer to *Homo sapiens* (Beck 1982;
The cases of bee language, or of individual recognition (e.g., face discrimination) in insects, could be used to enlarge the biological database to which compare human cognitive competences: «Investigations of human nature may benefit greatly from phylogenetic comparisons much broader than commonly applied. Even quite distant species may reveal things (about ourselves) which under a strict chimpocentric approach would have gone unnoticed» (Vaesen 2014, 20). An effective comparative approach that could reveal that the cognitive capacities similar to those of Homo sapiens are not those of chimpanzees or bonobos, but those of bees or chickens. It would be a hard blow for our anthropocentrism, but anthropocentrism should not take place in science.

3.1. DO DOGS AND BEES POSSESS A THEORY OF MIND?

This a rhetorical question which was the title of a paper published on *Animal behaviour* (van Rooijen 2010). A simpler and theoretically more sober description of animal behaviour would be possible if one observes the social behaviour of animals other than chimpanzees, such as dogs or bees. Consider the case of dog pointing, for example: «Pointing and the reaction to it, in all species with a cooperative foraging strategy, are the result of a natural selection without the necessity of assuming a presence of insight» (van Rooijen 2010, p. e8) into the other’s mind. That is, it is not necessary to presume the existence of a theory of mind (ToM) in dogs or bees to understand and explain their social behaviour. Equivalents of pointing have been described recently in Australian magpies (Kaplan 2011).

The case of insect cognition raises a similar problem for any «mentalistic» explanation of animal behaviour. When a bee «understands» the dance message of another bee, does it «believe» that the sender is honest about what it is communicating? Is such a mentalistic assumption necessary in order to explain bees’ communicative behaviour? We do not think so (Wray et al. 2007). Consider the case of individual recognition in wasps. Is there really someone who is willing to attribute to a wasp any representation of the other’s (wasp) mind? However, when a dog approaches the door, we all are well disposed to attribute to it some sort of «intention» to walk out in the garden. Why such a difference, why what in a case seems so odd suddenly becomes
obvious in another one? Maybe the difference is not to be searched into the dog or wasp mind, rather in our unconscious anthropomorphic assumption that an animal that resembles us cannot lack intentions and desires. A wasp face is so incredibly different from a human face that we have no foothold to which to hang any mentalistic attribution. At the same time, when we study insects or other «simple» animals (like chicken) we are astonished by their very complex behaviours. On the contrary, a similar behaviour in «superior» animals (that is, animals that in some way resemble humans) naturally seems to imply complex cognition, ToM and so on.

Consider the case of a famous paper on chimpanzees (Hare et al. 2000; here we do not want to discuss the enormous and controversial literature which followed this paper. What we want to stress is the theoretical point of the double standard used for primates and all other animals). The paper’s title is quite provocative: «Chimpanzees know what conspecifics do and do not see». The point is in the verb «to know», which in western folk psychology implies the presence of a so called «inner mental state». A completely different feeling would have been elicited in the reader if the title had been «Chimpanzees see what conspecifics do and do not see». The actual behaviours were that «in food competition situations subordinates chose to go for food that dominants could not see rather than food that they could see» (p. 783). Paraphrase: a chimpanzee avoids all situations where another dominant animal could prevent it to reach the food. Nevertheless, since the animal is a primate it is easy to attribute to it the same state we would attribute to us. Maybe too easy. But what if the animal was an insect? A cockroach comes out of the holes in the kitchen walls when there is no people in the surroundings; but as it realizes that there is someone it suddenly hides. That is, it only comes out when it «knows» that “dominants” do not «see» that it is in a certain place. While we all agree in considering such a mentalistic paraphrase of the cockroach’s behaviour undue, we are eager to consider chimpanzee’s behaviour much more clever and «mindful» than that of an insect: «One cannot ascribe the presence of gaze sensitivity to cognitive mechanisms such as perspective taking or attention attribution simply based to on the complexity of behaviours observed when animals gather visual information» (Davidson et al. 2014, 11).

This discussion does not imply at all to come back to simpler behaviouristic descriptions of animal behaviour. In fact we need an al-
ternative to the old dichotomy behaviouristic/mentalistic explanation (van der Vaart et al. 2012; Penn, Povinelli 2013).

The main problem with purely behavioural explanations – based on behavioural rules acquired through past-history of reinforcement contingencies of an organism – is that it would be possible to explain almost every cognitive feat by ad-hoc behavioural rules, acquired in some hypothetical past situation (Tomasello, Call 2006). On the other hand, attribution to animals (humans included) of capabilities labeled as «theory of mind» would prove meaningless without a precise definition of the computational mechanisms involved. It could be, however, that behavioural rules that can account for apparently complex cognitive feats would prove limited in numbers and capable to explain a large amount of data. An example is the recent attempt to account for the abilities of scrub jays (a corvid species) to re-catch food items when catching while they watched by conspecifics but not when catching in private (Emery, Clayton 2001). This behaviour could be interpreted as evidence for rudiments of a theory of mind (other birds intend to steal my food…) or, alternatively, the outcome of the use of behavioural rules (cache far away from onlookers…) that scrub jays learned in daily life. Recently van der Vaart et al. (2012) developed a theoretical model and simulations showing that a simple behavioural rule can account for scrub jays behaviour, namely that re-caching is motivated by a general aim to cache more and not to make a deliberate effort to protect caches from theft. The aim is brought on by stress, with consequent memory errors, associated with the presence and dominance of conspecifics onlookers, and by unsuccessful recovery attempts. Virtual birds operating on simulations act as real birds do, showing re-caching whether they have been watched and how close and how dominant was the onlooker. As recognized by the authors, this does not prove that scrub jays do not attribute mental state, but nonetheless show that mental state attribution is not needed to explain the behaviour. A small further step that we would suggest is to consider the possibility that similar explanations also hold for human behaviour. If so, what about the humans’ feeling and verbal reports of mental state attribution? Well, one possibility is that they are generated as a result of the possess of language in order to provide a rationale for behaviour during inter-individual communications (i.e. to describe the why of behaviour to others), without actually playing any role in behaviour per se. According to this hypothesis human beings self-de-
scriptions would be not external reports of internal processes, instead they would be what psychoanalysts call the «self». In such a perspective self-consciousness, as long time ago Freud imagined (Freud 1891), is this succession of self-descriptive sentences. The idea is that the «I» is exactly this uninterrupted stream of linguistic acts. From this point of view such sentences are more than «descriptions» of internal states, they literally are such states (Dennett 1992).

4. WHAT ARE BIG BRAINS FOR?

A puzzle associated with insects abilities for some alleged sophisticated cognitive feats is their small brains. If small brains can deal with tasks like face recognition, categorization and the like, what is the reason for the large number of neurons we can count on mammals or birds? We meant to say not just humans (one could argue, very likely wrongly, that the 86 billions of neurons of the human brain are associated with language and symbolic processing) but non linguistic creatures like rats, fish or chicken that have huge brains when compared to honeybees. Well, the most obvious answer is to argue that, counterintuitively, complex cognition can be done with just a few neurons, whereas it is detailed sensory and motor activities that require a lot of neurons (see also Chittka, Niven 2009). Neural networks studies show, for instance, that a few hundreds neurons suffice to make computations needed for a reliable face recognition mechanism (for a review see Chittka, Niven 2009). Such numbers can be easily accommodated in a honey bee brain. So what is the difference between face recognition in a honey bee and a human or a monkey that would explain why the latter needs more neurons? The mundane answer could be that humans can do that with much more fine spatial resolution. This is not just for face recognition but for vision in general. In order to have higher visual acuity in fact, increasing the number of receptors is not enough, a parallel increase in the neurons elaborating their signals is needed too. The same is true for motor systems: higher degree of sophistication and control requires more neurons. We usually do not consider these computations «intelligence» but they are in fact. In general, larger brains contain mere replication of neuronal circuits, which would add precision to sensory processes, as well as more massive parallel processing and enlarged storage capacity. Again, we usually do not consider large storage
capacity as a measure of intelligence. But it could account for qualitative differences between insect cognition and large-brained animals cognition. How many faces could a honeybees remember? We guess just a limited number compared to a sheep (Kendrick et al. 2001) or a human (Russell et al. 2009).

4.1. ETHICAL CONSEQUENCES

The case of individual recognition in insects (Tibbets 2002; Sheehan, Tibbetts 2011) raises a serious ethical problem. One of the basic prerequisite for every ethical perspective is the possibility to distinguish between different individuals in a group. Ethics implies that individual A is different from individual B. When all members of a group are intrinsically indistinguishable no ethics is possible, because in principle there is no possibility to distinguish who does that from who does this. Now, if a wasp A recognizes another wasp as that wasp, which is different from all other wasps, the situation could present itself that A showed some peculiar behaviour for a specific wasp only. That is, it could be the case that A shows what in other animals (mammals, birds and perhaps other vertebrates) we could be willing to describe as interests and preferences at least in the field of social interaction. In such a case, how could we get rid of any ethical consideration toward insects? How can we assert that «simple creatures like honey bees [...] never suffer» because «suffering requires the cognitive awareness of pain» (Tye 1997, 310)? If wasp A sees another wasp which is accustomed to spend a lot of time together with, who finds itself in a dangerous situation, how can we be so sure that nothing is going on in A’s mind? Even in the case that A does not know that it is suffering, A is perceiving something that maybe it does not like to see, because A prefers that individual to all other individuals of its social group. Our point is not that insects show some precursor of human ethics, nor that they should be considered as ethical entities (at least from our point of view). What we simply want to stress is that insects are not that simple automatic machines as it is so easy and comfortable to believe (Eisemann et al. 1984; Fiorito 1986; Carruthers 2007; Elwood 2011). Such a point of view would not be challenged even in the case that insects pain-behaviour were based on «simple» nociceptive mechanisms. From an ethical point of view an organism which somewhat
«participates» to the pain of another organism (an event that insects individual recognition makes possible) it is worth be considered differently from an inanimate object. It is not at all clear – at least from a biological point of view – why the mere fact that our pain-bahaviour included verbal reports made it more ethically relevant than the pain behaviour of a mute (at least from our listening point) organism.

The final point we want to stress is that the new and unexpected picture of the insect mind that recent scientific discoveries are delineating poses a serious challenge to the established idea of human position in nature, both from a cognitive and an ethical point of view.

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