# The Role of Human Creativity in Understanding Animal Cognition

**Sartaj S. Ghuman[1], Rajesh Kasturirangan[2] and Anindya Sinha[1,3,4]**

[1]School of Natural Sciences and Engineering, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560012, India

[2]School of Humanities, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore 560012, India

[3]Centre for Neuroscience, Indian Institute of Science, Bangalore 560012, India

[4]Nature Conservation Foundation, 3076/5, 4th Cross, Gokulam Park, Mysore 570002, India

**Workings of the human mind**

We are constantly trying to make sense of the world around us. As this world is densely populated by animate beings, predicting their behaviour is a major part of this task. In our daily lives, we constantly impute mental states like desires, beliefs and emotions to others, in order to explain their behaviour and to predict their future actions. Such a system of inferences has been called a 'Theory of Mind'. 'Theory', as first, such states are not directly observable and second, because the system is used to make predictions about the behaviour of other individuals (Premack and Woodruff 1978).

The mental states that we attribute to others are based on our own subjective experience of these states. We do not have direct access to other minds, but it is a reasonable assumption that all human minds are alike in their basic functioning, with obvious individual variations. One can, therefore, be justified in extrapolating feelings to others from what one experiences. The inference or prediction is then borne out by their subsequent actions and our theories of how others behave and think, improve over time. These can also be then validated through verbal feedback when we talk to the people around us. The greatest drawback when studying nonhuman animal cognition, however, is the nearly complete absence of self-report in our

subjects. But this need not be as big a deterrent as it is often made out to be, not any bigger than it is in the study of babies, or people of other ethnic groups who speak a language that you do not.

We, however, often end up at either one of two extremes when dealing with animal minds, attributing to a particular animal all human cognitive capacities, or else treating it as little more than an automaton. What differs from one narrative to the other is usually where the line is drawn (Dawkins 1993). For instance, for some people it might be acceptable to attribute mental states to dogs but not to parakeets, while others may extend the boundary to include birds but not frogs.

The one obvious problem that such an approach creates is the misattribution of complex human capacities to animals without reasonable evidence. This could be because the human mind understands the world in terms of analogies (Holyoak and Thagard 1997, Gentner et al. 2001), mapping a known system onto an unknown one. This is evident in the most intuitive paradigm used in studying animal minds that has come under much criticism over time: inference by analogy.

This can be summarised as below:
1. Humans perform y, by capacity x.
2. The animal performs y,
3. Therefore, it must have capacity x

The approach depends extensively on similarity of form, expression, and structure. Though valid in some cases due to underlying evolutionary relations, it is hard to prove in most cases. A second problem with arbitrarily classifying animals into those with or without human-like cognitive capacities is that we might overlook interesting phenomenon just because it is too far removed from our own experience. For instance, how can we ever understand the navigational abilities of bees unless we start from first principles? Bees use cues that we are not even aware of with just our senses – the polarisation of light (Rossel 1993). Even the processing of the information happens in the structural processes of the eyes themselves. One must therefore realise that animals are adapted to not only specific ecological niches but also to specific cognitive niches and will have specialised cognitive modules as interesting as any that humans might have. The same objectivity, however, can be difficult to maintain when it

comes to studying primates. Distancing one's experience and investigating a cognitive ability for its own sake is easier for bees than for animals whose behaviour may resemble our own, like dogs or monkeys; but the effort must nonetheless be made.

**Paradigm shifts in primate cognition**

Animal cognition draws its roots from studies of human psychology as well as ethology. After the initial setbacks when the rise of behaviourism questioned the very basis of the study of animal cognition, a rigorous approach of testing for cognitive capacities in experimental setups was taken by the 1930s (Köhler 1925, Yerkes and Child 1927, Allen and Bekoff 1999). Over the next few decades, the experimental design evolved slowly but the changes were mainly in the capacities that the primates, mainly chimpanzees, were being tested for. With input from human psychology, testing for nonhuman primate capacities continued along a comparative route (Tomasello and Call 1997).

In the last few decades, however, there have been at least two major paradigm shifts, and these have yielded insights that would have been hard to come by otherwise. The first is the shift from human-animal interactions to animal-animal interactions in the experimental setup. In the classic 1978 paper (Premack and Woodruff 1978), wherein the question whether chimpanzees have a theory of mind was asked, Sarah, the chimpanzee under study, was shown video clips of human beings trying to solve a particular problem and then asked to choose one of three photographs that was the solution to the problem. One of the videos showed a human individual shivering next to an unplugged heater and Sarah was expected to choose the photograph which showed the heater plugged in. Irrespective of the fact that Sarah chose the correct photograph, it is clear that the experiment uses a scenario that a chimpanzee is rather unlikely to witness in the wild. The chimpanzee under study had been brought up in an unnatural setting and this could explain why she was able to perform well and positive results were possibly thus obtained; negative results in such a setup would, of course, be utterly inconclusive. In other, more recent, experiments, chimpanzees were expected to use cues like pointing by a human to obtain hidden food (Povinelli et al. 1997). This is a situation that would almost never occur in the wild, unrelated chimpanzees never help each other by pointing out food (Leavens et al. 2005). More and more experiments now use settings wherein an animal is expected to interact with another animal rather than with a human being (Hare et al. 2000, Hare et al. 2001). This is not only more natural but also makes the results obtained more amenable to extrapolation to animals in the wild.

The second, more important shift that these experiments embody is from esoteric models to more functional, ecologically valid tasks. Co-operative tasks, like humans pointing out food to chimpanzees, have given way to competitive paradigms wherein two animals are expected to compete for food (Hare 2001, Hare et al. 2001) and instead of testing for concepts like 'theory of mind' we are now looking at whether the animals know what others can or cannot see, or whether they know what others do or do not know (Hare et al. 2000, Povinelli and Eddy 2000, Flombaum and Santos 2005, Santos et al. 2006). By giving up a-priori thought-out models and by instead trying to build bottom-up cognitive models that incorporate capacities actually observed in primates, we hope to effectively build a functional model that is not human-centric.

In fact, there seems to have been a marked shift in the underlying ideology. The tacit framework that people worked with was an evolutionary ladder with man on top and various species lining the rungs. This is slowly but surely being replaced by a more encompassing view of the evolutionary tree with each animal occupying a specialised niche and having a set of cognitive mechanisms to meet the demands of survival, none obviously superior to the other.

**Current debates in primate cognition**

The current debates in animal cognition revolve around three basic questions: what to look for, how to look for it and how to interpret what you see (Penn and Povinelli 2007, Call and Tomasello 2008). The first question deals with whether we ought to invest time and energy in testing for capacities that we know to be cognitive complex and that are exhibited by humans, in other animals. It is argued that we ought to look for the capacity for recursion, or language, grammar or some other such capacity because we know these to be cognitively complex and they thus provide us with good starting points (Lakshminaryanan et al. 2008, Peeters et al. 2009, Krachun et al. 2010). But the opposite view is that we must test for ecologically valid capacities (Bicca Marques and Garber 2004, Santos et al. 2006, Hostetter et al. 2007). We ought to begin with the animal as it exists in its environment, occupying the niche that it inhabits and proceed to understand how it manages to live its life in its own way. We must begin to appreciate that navigation and foraging in bees or in monkeys is a very complex task and worth understanding in its own right. This latter is an exciting approach because it does away with the human-centric perspective and opens up the field for truly understanding other

animals as they are and not as almost-humans. And since the cognitive niche is related to the ecological niche of the species, it is more amenable to a functional approach and thus more tractable than attempts at arriving directly at mental states.

The second question about how to go about the investigation is subdivided under categories of what is to be investigated. To understand animal minds and how they represent other minds has been a long-standing topic of investigation. The competitive tasks that try to understand whether animals know what others can or cannot see under specified experimental conditions have been criticized mainly for their failure to negate simple alternative hypothesis and experience-transfer paradigms have been suggested as better options to explore (Povinelli and Vonk 2003). Experience-transfer experiments test whether an animal can predict the behaviour of another animal when the latter is placed in circumstances that the former has been in (Povinelli and Vonk 2004). It has, however, also been pointed out that this paradigm too suffers from the same short-comings that it strives to eradicate (Bloom and German 2000). This is best illustrated in the false-belief task and brings us to the third and last question about the interpretation of the obtained results.

The false-belief task, which has been modified and used extensively in animal studies, has been shown not to be fool-proof even for humans (Bloom and German 2000). There is more to the false-belief task than just invoking theory of mind, for it requires sequential memory and memory slots. On the other hand, individual animals could also accomplish the standard false-belief task using simple heuristics without any access to a theory of mind. The challenge here is that more than one mental state can lead to the manifestation of the same behaviour and as the observer has access to only the observable behaviours, one can never unambiguously establish the appropriate mental state involved or the cognitive mechanism in question. For instance, when an animal predicts the behaviour of another animal in an experimental paradigm, it is impossible to know whether it relies on something like a statistical probability of a particular behaviour occurring or a true attribution of mental states corresponding to the observable behaviour.

We are thus currently at a point where the methodology currently in practice is being questioned and we need a fresh paradigm that will allow us to make progress while laying foundations that are unambiguously solid.

**A promising perspective to adopt**

One interesting paradigm to adopt is to take up a functional rather than a phenomenological approach, and that informed by field studies. To cite just one instance of what such an approach can yield, Menzel (Menzel 1966, Menzel 1997), through simple experiments in the wild, demonstrated the flexible and highly adaptable foraging patterns of Japanese macaques by recording their response to fruits and chocolate placed by the sides of trails. These are ecologically valid paradigms that test for capacities that the animals need in their daily lives and which one can expect to be selected for. Instead of asking whether animals have a mind, the question we ought to be asking is, what sort of a mind do they have? How do they forage, or navigate, or find mates? These are ecologically relevant problems that the animal needs to solve in order to survive.

Every organism is shaped through evolution to fit a specific niche. Over evolutionary time, organisms become better adapted at exploiting certain resources and overcoming certain problems that are associated with the ecological niche that they inhabit. Advantageous traits are selected for over generations and come to be known as adaptations. Everything from the broad leaves of evergreen trees competing for sunlight to the gecko's camouflage is an adaptation that makes it that much more successful in life – in terms of its survival and reproduction (Benitez-Vieyra 2007, Peter 2008).

Adaptations can be broadly classified as being morphological, physiological or behavioural. Most behavioural adaptations are selected to overcome largely stable problems that change little over evolutionary time. Some of these may emerge during the individual's lifetime as fixed action patterns or behavioural tendencies like the classic egg-retrieval behaviour displayed by Greylag geese (Lorenz and Tinbergen 1938). Yet others may involve incorporation into an individual's behavioural repertoire through a variety of hierarchical learning mechanisms (Whiten 2000). Some organisms, however, face complex problems that are of a more mercurial nature and often subject to such rapid change such that to tackle them may require a switch in strategies during a single lifetime. At their extreme there are ecological, and many a times, social contexts that require an individual to constantly take decisions about the best behaviour to deploy in real time. Behavioural adaptations that are of such a nature, that is, flexible, generalisable and adaptable to novel situations, are called cognitive adaptations.

In a recent study, we studied tactical deception in bonnet macaques, a common cercopithecine monkey endemic to peninsular India. The popular definition of deception today is the one that Byrne and Whiten (1985) used when reporting acts of deception in a troop of baboons and which they later improved upon (Whiten and Byrne 1988, Byrne and Whiten 1992). They functionally define *tactical deception* as *acts from the normal repertoire of the agent, deployed such that another individual is likely to misinterpret what the acts signify, to the advantage of the agent.*

It has been called tactical deception as it deals with short-term 'tactics' in which the deception uses elements from an honest counterpart in the individual's repertoire, as against long-term 'strategies' like mimicry and camouflage where the honest and deceptive versions of anatomy or behaviour typically occur in distinct individuals or different species.

Tactical deception can thus be considered a special case of signalling in animal communication. Topi antelope males, for example, who defend territories that females pass through, may use an alarm call which usually signals the presence of a predator, in the absence of any real threat, to keep the females from leaving their territory and thus increasing their own chances of successful mating (Bro Jørgensen and Pangle 2010). Such behaviour has obvious fitness benefits and would thus be selected for. In bonnet macaques, however, tactical deception is relatively more widespread. Though the instances recorded may be few and far between, the behaviour used was found to be highly variable. They used not only alarm calls but also affiliative behaviours like allogrooming or threat displays in situations out of context. And all of these behaviours were used in circumstances that were highly variable, as, for example, to disrupt the mating of other individuals, avoid aggression or even sneak copulate. We also recorded controls for many of these behaviours, wherein the individuals used tactical deception in one situation but not in other, seemingly similar situations. This variability, which indicates flexibility in the deployment of the behaviour, the presence of controls and their ability to adapt the behaviour to novel situations seem to suggest that tactical deception in bonnet macaques is a cognitive capacity.

**Biosemiotics**

Biosemiotics is the study of the myriad forms of communication and signification observable both within and between living systems (Sebeok 2001, Favareau 2010). It studies the production, action and interpretation of signs in the biological world. The signs in the world

are indeed the regularities that animals access, and thus it allows a systematic investigation into the flexibility and generalisability with which these regularities are accessed.

Regularities, simply put, are probabilistic conjunctions of phenomena. These may be morphological features of objects, or their manifest properties under given circumstances or even the high statistical probability of a sequence of occurrences. This co-occurrence happens through constraints that limit the scale, dimensions or probabilities of interactions and inter-relationships (Deacon 2007). And it is by virtue of regularities among connections that information about some components of a distributed system carries information about other components (Barwise and Seligman 1997). Regularities thus act as signs that animals access directly in the course of their lives (Favareau 2009).

Animal signals, for instance, operate because the receiver has prior information about the regularities in the behaviour of the signaller. This is possible because the 'experience' of the lawfulness of the behaviour of animals gets internalised in the brain of the receiver either evolutionarily or through learning during the individual's lifetime (Krebs and Dawkins 1984). Similarly, it is possible to investigate the categorisation abilities of animals and know what cues they use during these processes (Fabre-Thorpe et al. 1998, Fabre-Thorpe 2003, Macé et al. 2005).

If the ultimate goal of animal cognition is to know what it is like to be an animal, knowing what cues the animals use should be one of the essential components of our endeavour. We must appreciate the regularities that they access and the kind of processing that occurs. This will contribute significantly to a comprehensive account of the animal's *umwelt*, its own self-centred world where the exchange of both information and energy takes place (Deely 2004). It is obviously easy to have anthropomorphic accounts of animal behaviour; what is far more challenging, however, is to arrive at an animal-centric narrative as the latter clearly requires us to be far more imaginative.

**References**

Allen, C. and Bekoff, M. 1999. *Species of Mind: The Philosophy and Biology of Cognitive Ethology*. The MIT Press, Cambridge, USA.

Barwise, J. and Seligman, J. 1997. *Information Flow: The Logic of Distributed Systems*. Cambridge Univ Press, Cambridge.

Bicca Marques, J. C. and P. A. Garber. 2004. Use of spatial, visual, and olfactory information during foraging in wild nocturnal and diurnal anthropoids: A field experiment comparing Aotus, Callicebus, and Saguinus. *American Journal of Primatology* **62**, 171-187.

Benitez-Vieyra, S., De Ibarra, N. H., Wertlen, A. M. and Cocucci, A. A. 2007. How to look like a mallow: Evidence of floral mimicry between Turneraceae and Malvaceae. *Proceedings of the Royal Society B: Biological Sciences* **274**, 2239-2248.

Bloom, P. and German, T. P. 2000. Two reasons to abandon the false belief task as a test of theory of mind. *Cognition* **77**, B25-B31.

Bro Jørgensen, J. and Pangle, W. M. 2010. Male topi antelopes alarm snort deceptively to retain females for mating. *American Naturalist* **176**, E33-E39.

Call, J. and Tomasello, M. 2008. Does the chimpanzee have a theory of mind? 30 years later. *Trends in Cognitive Sciences* **12**, 187-192.

Dawkins, M. S. 1993. Through our eyes only? The search for animal consciousness.

Deacon, T. W. 2007. Shannon–Boltzmann–Darwin: Redefining information (Part I). *Cognitive Semiotics* **1**, 123-147.

Deely, J. 2004. Semiotics and Jakob von Uexküll's concept of umwelt. *Sign Systems Studies* **32**, 11-34.

Fabre-Thorpe, M. 2003 Visual categorization: Accessing abstraction in non-human primates. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences* **358**, 1215-1223.

Fabre-Thorpe, M., Richard, G. and Thorpe, S. J. 1998. Rapid categorization of natural images by rhesus monkeys. *Neuroreport* **9**, 303-308.

Favareau, D. 2009. The Theory of Meaning. In: *Essential Readings in Biosemiotics* (Favareau, D.), Springer, Berlin, pp. 81-114.

Flombaum, J. I. and Santos, L. R. 2005. Rhesus monkeys attribute perceptions to others. *Current Biology* **15**, 447-452.

Gentner, D., Holyoak, K. J. and Kokinov, B. N. 2001. *The Analogical Mind: Perspectives from Cognitive Science.* The MIT Press, Cambridge, USA.

Hare, B. 2001. Can competitive paradigms increase the validity of experiments on primate social cognition? *Animal Cognition* **4**, 269-280.

Hare, B., Call, J., Agnetta, B. and Tomasello, M. 2000. Chimpanzees know what conspecifics do and do not see. *Animal Behaviour* **59**, 771-785.

Hare, B., Call, J. and Tomasello, M. 2001. Do chimpanzees know what conspecifics know? *Animal Behaviour* **61**, 139-151.

Holyoak, K. J. and Thagard, P. 1997. The analogical mind. *American Psychologist* **52**, 35-44.

Hostetter, A. B., J. L. Russell, H. Freeman, and W. D. Hopkins. 2007. Now you see me, now you don't: evidence that chimpanzees understand the role of the eyes in attention. *Animal Cognition* **10**, 55-62.

Köhler, W. 1925. *The Mentality of Apes.* Harcourt, Brace and World, New York.

Krachun, C., M. Carpenter, J. Call, and M. Tomasello. 2010. A New Change-of-Contents False Belief Test: Children and Chimpanzees Compared. *International Journal of Comparative Psychology* **23**, 145-165.

Krebs, J. R. and Dawkins, R. 1984. Animal signals: mind-reading and manipulation. In: *Behavioural Ecology: An Evolutionary Approach* (eds. Krebs, J. R. and Dawkins, R.), Blackwell Scientific Publications, Oxford, pp. 380-402.

Lakshminaryanan, V., M. Keith Chen, and L. R. Santos. 2008. Endowment effect in capuchin monkeys. *Philosophical Transactions of the Royal Society B: Biological Sciences* **363**, 3837-3844 .

Leavens, D. A., Hopkins, W. D. and Bard, K. A. 2005. Understanding the point of chimpanzee pointing: Epigenesis and ecological validity. *Current Directions in Psychological Science* **14**, 185-189.

Lorenz, K. and N. Tinbergen. 1938. Taxis and instinctive behavior pattern in egg-rolling by the Greylag goose. *Studies in Animal and Human Behavior* **1**, 316-359.

Macé, M. J. M., Richard, G., Delorme, A. and Fabre-Thorpe, M. 2005. Rapid categorization of natural scenes in monkeys: Target predictability and processing speed. *Neuroreport* **16**, 349-354.

Menzel, C. R. 1997. Primates' knowledge of their natural habitat: As indicated in foraging. *Machiavellian Intelligence II: Extensions and Evaluations* (eds. Whiten, A. and Byrne, R. W.), Cambridge University Press, Cambridge, pp. 207-239.

Menzel, E. W. 1966. Responsiveness to objects in free-ranging Japanese monkeys. *Behaviour* **26**, 130-150.

Peeters, R., L. Simone, K. Nelissen, M. Fabbri-Destro, W. Vanduffel, G. Rizzolatti, and G. A. Orban. 2009. The representation of tool use in humans and monkeys: common and uniquely human features. *The Journal of Neuroscience* **29**, 11523-11539.

Penn, D. C. and Povinelli, D. J. 2007. On the lack of evidence that non-human animals possess anything remotely resembling a 'theory of mind'. *Philosophical Transactions of the Royal Society B: Biological Sciences* **362**, 731-744.

Peter, C. I. and Johnson, S. D. 2008. Mimics and magnets: The importance of color and ecological facilitation in floral deception. *Ecology* **89**, 1583-1595.

Povinelli, D. J. and Eddy, T. J. 1996. What young chimpanzees know about seeing. *Monographs of the Society for Research in Child Development* **61**, 1-191.

Povinelli, D. J., Reaux, J. E., Bierschwale, D. T., Allain, A. D. and Simon, B. B. 1997. Exploitation of pointing as a referential gesture in young children, but not adolescent chimpanzees. *Cognitive Development* **12**, 423-461.

Povinelli, D. J. and Vonk, J. 2003. Chimpanzee minds: Suspiciously human? *Trends in Cognitive Sciences* **7**, 157-160.

Povinelli, D. J. and Vonk, J. 2004. We don't need a microscope to explore the chimpanzee's mind. *Mind and Language* **19**, 1-28.

Premack, D. and Woodruff, G. 1978. Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences* **1**, 515-526.

Rossel, S. 1993. Navigation by bees using polarized skylight. *Comparative Biochemistry and Physiology Part A: Physiology* **104**, 695-708.

Santos, L. R., Nissen, A. G. and Ferrugia, J. A. 2006. Rhesus monkeys, *Macaca mulatta*, know what others can and cannot hear. *Animal Behaviour* **71**, 1175-1181.

Sebeok, T. A. 2001. Biosemiotics: Its roots, proliferation, and prospects. *Semiotica* **134**, 61-78.

Tomasello, M. and Call, J. 1997. *Primate Cognition*. Oxford University Press, New York.

Whiten, A. 2000. Primate culture and social learning. *Cognitive Science* **24**, 477-508.

Yerkes, R. M. and Child, M. S. 1927. Anthropoid behavior. *Quarterly Review of Biology* **2**, 37-57.