A beautiful mind: Attribution and intentionality in wild bonnet macaques*

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Empirical and observational studies of animal cognition will truly benefit if different behavioural manifestations of higher cognitive processes can be defined functionally. This is vitally important because, when studying animals, cognition has to necessarily manifest in behaviour for it to be tractable, and the performance of such behaviour, in turn, needs to be unambiguously ascribed to an effect of particular cognitive processes. One theoretical framework to investigate cognition in animals in terms of mentalistic notions is that of the intentional stance, which assumes that each individual is an intentional system capable of mental states like beliefs, desires and emotions. To attribute such mental states to both oneself and to others is to have what has been termed a theory of mind. Social primates appear to be knowledgeable about one another's behaviour to different extents. But do they know as much about one another's beliefs and intentions? Are they adept at recognizing the similarities and differences between their own and others' states of mind? Attribution of mental states to other individuals could manifest itself in diverse situations as, for example, when individual animals closely observe the actions of others, when they interact competitively, or when they deceive each other in the social sphere. Such behavioural constructs need to be analysed carefully in order to ascertain whether true higher-order intentionality can indeed be invoked as underlying mechanisms governing these acts. This article examines the possible cognitive bases of social knowledge-based decision-making and tactical deception, processes that appear to be integral to the development and maintenance of social relationships in wild bonnet macaques (*Macaca radiata*), a primate species endemic to peninsular India.

EMPIRICAL studies on the cognitive abilities of non-human primates and their underlying mechanisms developed primarily because we assume that their intelligence and, if one may use the term, minds are most like our own. Through our understanding of them, we would possibly one day understand what it is like to be essentially human. However, this view that they are most like us also coexists in our minds with the equally pervasive idea that non-human primates differ fundamentally from us because they lack sophisticated language, and may, thus, also lack some of the capacities necessary for reasoning and abstract thought. Given the recent developments in our understanding of the cognitive abilities of many primates, including the possible existence of rudimentary semantic communication in some species[1,2], nevertheless, comparative studies on primate taxa may yet throw light on the nature and evolution of different human cognitive abilities, including that holy grail of current cognitive research – consciousness[3].

This article first briefly reviews some theoretical approaches that utilize observations of behaviour to examine the phenomenon of the animal mind. Two specific examples of social behaviour, knowledge-based decision-making and tactical deception displayed by bonnet macaques are then examined in terms of the possible underlying cognitive processes in an effort to obtain some glimpses into the non-human primate mind.

The primate mind

A feature that commonly characterizes most primates, including the great apes and humans is the presence of a complex society in which individuals spend most of their lives. Extensive social interactions among individuals of different ages, sexes, dominance ranks and kinship are typical of many of these societies[4]. The development and maintenance of such complex social relationships – each different in its own way – are believed to have placed unusual demands and selected for enhanced cognitive abilities in individuals living in such societies[5–7]. If this is true, and if indeed there has been a general increase in social complexity – in at least some of its dimensions – during the course of primate evolution, does this provide at least indirect evidence that there has been a progressive evolution of the primate mind, culminating in the human mind as well?

Although there is now increasing belief that primate minds can be rather complex, the question of whether non-human primates can be considered truly conscious

continues to be a controversial one. Related to this problem is perhaps one of the most difficult aspects of studying consciousness – that of providing an objective scientific definition of the phenomenon. This definition obviously has to be functional in order that it can be dissected out analytically. And it becomes an even greater problem when studying non-human primates – because consciousness then has to manifest itself in behaviour – behaviour that can be unambiguously ascribed to being an effect of being conscious.

Of the numerous definitions of consciousness that exist in the literature, perhaps the most functional that have been proposed are *perceptual consciousness*, the ability to possess certain mental states, including emotions, thoughts, beliefs, desires or memories, and *reflective consciousness*, the recognition by the thinking subject of its own perceptions and mental states[3]. In other words, if an animal were perceptually conscious, it would be able to possess certain mental states – it might, for example, be able to believe, think or remember. If, in addition, it were reflectively conscious, it would be aware of its own mental states – whether they are beliefs, thoughts or memories. Current thinking holds that some of the higher primates may indeed be perceptually conscious, but are extremely unlikely to be reflectively so[1]. The principal reason for this bias against the belief that primates can reflect on their thoughts and actions may, however, largely be methodological: people can tell us what they are aware of, monkeys cannot.

Intentionality and attribution

Functionally, an elegant theoretical framework to investigate higher cognitive processes in non-human primates in terms of mentalistic notions is that of Dennett's *intentional stance*[8,9]. If one assumes that animals are intentional systems capable of mental states like beliefs, desires and emotions, it is possible to consider them as beings with different levels of intentionality. Note that a particular individual of any species can be in different intentional states depending on the cognitive basis of the particular behaviour performed. Under this framework, however, each species has a unique position with regard to the highest order of intentionality that it can ever achieve, although lower-order intentional behaviours can always be exhibited.

To give an example (adapted from ref. 1), bonnet macaques typically give alarm calls to potential predators such as leopards or wild dogs. On hearing an alarm call given by a particular individual, the other troop members immediately run up trees and then scan for the predator. Theoretically, this behaviour could be considered under different orders of intentionality, as explained below, although studies in cognitive psychology will aim to determine exactly which order it belongs to.

Zero-order

An individual has no beliefs or desires at all. All behavioural actions in this category are thus instinctive, invariably evoked in response to specific stimuli.

If the bonnet macaque alarm call truly belongs to this category, it must be hypothesized that bonnet macaques give alarm calls as a mere response to a stimulus – the sight of a predator – and no actual desires or beliefs are involved in this reaction.

First-order

An individual has beliefs or desires, but no beliefs about beliefs. Behavioural acts can thus be generated intentionally by the actor who, however, need not have any conception of the audience's mental states.

In this case, therefore, bonnet macaque alarm calls are given because the caller believes that there is a predator nearby, although it may have no comprehension of the belief system of its troop members.

Second-order

Some conception exists about both one's own and other individuals' states of mind. An individual may thus behave in a particular way because it wants others to believe in something.

A bonnet macaque may thus give alarm calls because it wants its troop members to believe that there is a predator lurking nearby.

Third-order

At this level, an individual may want others to believe that it has a particular belief or is in a specific emotional state, or that it wants others to believe that it wants them to respond in a particular manner.

If bonnet macaques are truly third-order intentional systems, an alarm call may be given because the caller wants the other individuals to believe that it wants them to rush up the trees.

Human beings are typically third-order intentional systems exhibiting a wide variety of behaviours that can be classified under different orders of intentionality. When a human subject removes a finger from a pinprick or a flame involuntarily, for example, it is a zero-order intentional system, since there are no desires or beliefs associated with this behavioural act. Human linguistic communication, on the other hand, is a notable example of a system where the actor (or speaker) makes its own mental states apparent to the audience; this clearly and essentially requires third-order intentionality.

Higher-order intentionality (including second- and third-order levels) is interesting because it requires the ability to represent simultaneously two different states of mind – that of the actor and of the audience. To do this, an individual must recognize, for example, that it has knowledge, others have knowledge, and that there may be a discrepancy between them – or, for that matter, between any of the intentional states held by these two minds. Unfortunately, very few studies – either in the wild or in captivity – have so far extensively tested for these alternative capacities of intentionality in primates.

An important functional manifestation of higher-order intentionality, and also of perceptual consciousness, is *attribution*, whereby an individual is capable of attributing thoughts, emotions and desires to another individual (reviewed in ref. 1). It is evident that primates are knowledgeable about each other's behaviour, to the extent that they can often predict and act upon this knowledge even before a behavioural interaction has occurred[10]. But do primates know as much about each other's beliefs, emotions and intentions? To attribute beliefs, knowledge and emotions to both oneself and to others is to have a *theory of mind*, first outlined by Premack and Woodruff[11]. And if indeed primates are able to attribute a mind – or more functionally, mental states – to each other, are they capable of recognizing the similarities and differences between their own and others' states of mind as well?

The principal advantage that an animal enjoys if it is able to recognize that other individuals have beliefs which might be different from its own, is that it becomes capable of immensely more flexible and adaptive behaviour. It might then be able to manipulate another individual's actions and beliefs in a great variety of social situations. Furthermore, if it can recognize ignorance in others, it can selectively reveal and withhold information from them. Again, novel information can be transmitted across individuals by active teaching rather than by the relatively slow process of observational learning. However, there has almost been no such systematic studies of attribution of mental states in social animals, including non-human primates except in the great apes (reviewed in refs 1 and 2).

Predicting behaviour or predicting mental states?

Perhaps the most difficult problem in understanding cognitive processes in non-verbal subjects – be they pre-verbal human infants or truly non-verbal primates – is the question of whether an individual is discriminating between others' states of mind or simply reacting to differences in their behaviour patterns. While it is evident that true mind-reading can only be achieved through some form of behavioural analysis and can, therefore, perhaps be considered a sub-category of behaviour-reading[12,13], it becomes important in certain situations, as, for example, in the analysis of deceptive interactions, to differentiate between actual behaviour analysis and the more cognitively sophisticated (as well as evolutionarily advanced?) mentalism. Although many philosophers of mind have argued that these two processes represent mutually exclusive phenomena (for example, ref. 14), it can be better argued and examples provided from human cognitive processes to demonstrate that they represent two positions on a possible continuum (see also ref. 15).

A theoretical concept of how mental states could be considered as intervening variables, facilitating the recognition of a number of otherwise complex stimulus–response links (each of which could independently form the basis of a behaviour-reading process) has been elegantly proposed by Whiten[12,13]. Drawing from an earlier concept in psychology, it suggests that any number of observable conditions could lead an individual to recognize a certain specific mental state in another individual, and once this state has been attributed, to predict a definable number of behavioural outcomes depending on the ambient situation. A crucial advantage of this model is that the coding of each of these intervening variables (or the so-called mental states) would be more 'economic of representational resources'[13] than would be the multitude of the stimulus–response links that each now represents. This is particularly true for mental states which are achievable by many different conditions and which can, in turn, affect a number of different outcomes. Mind-reading or the recognition of mental states, by such a definition, could thus constitute a more neurologically economic strategy than would a collection of independent stimulus–response pathways that represent behaviour-reading. Note also that according to this concept, mentalism arises gradually from behaviour analysis – if the intervening variable mediates the recognition of and response to only a single stimulus–response link, it is virtually indistinguishable from behaviour-reading.

Yet another line of evidence that can potentially argue for mentalism as an underlying cognitive process rather than simple behaviour analysis, at least in certain situations, is that of projection of experience[16] (succinctly reviewed in ref. 13). This has stemmed from studies on role reversal in cooperative tasks in which an individual primate was first trained to perform a definite task to aid another individual in reaching a desired goal, following which it was asked to take on the role of the other individual. These experiments have suggested that the great apes, notably chimpanzees, are able to master new roles with ease and perform novel tasks, perhaps because they can attribute beliefs and desires to one another; their performance cannot be explained by simple learning of the behaviour of their partner before role reversal. Rhesus

macaques, on the other hand, appear to lack empathy and, in order to successfully complete such cooperative tasks, have to learn their new roles afresh[17].

A philosophical assumption that seems to be implicit in all discussions over whether individual primates are able to recognize mental states or simply perform behaviour analysis is that principles of parsimony are violated when mind-reading is invoked in non-verbal non-human primates. Such an assumption perhaps owes its origin to the subtle influences that Biblical tradition and Cartesian philosophy seem to have had on Western scientific ideology, which has, often implicitly, valued the inherent superiority of man over all other forms of life. Although outside the scope of this article, it is important to stress here that it is perhaps now time to re-evaluate such an assumption, and concepts such as that of mental states as economical intervening variables, discussed above, are important steps in this direction (see also ref. 18).

In the remaining part of the article, the possible cognitive mechanisms involved in two complex social processes displayed by wild bonnet macaques – social knowledge-based decision-making and tactical deception – will be analysed. Particular attempts will also be made to explore the conceptual contribution that attribution of mental states as well as orders of intentionality could offer towards an understanding of these mechanisms.

Bonnet macaques – the species and the troops

The bonnet macaque (*Macaca radiata*), a cercopithecine primate found only in peninsular India, usually lives in large troops of 8 to 60 individuals; such multimale troops typically contain several adult males and females, as well as juveniles and infants of both sexes[19]. Female bonnet macaques, like many other cercopithecines, usually remain in their natal group throughout their lives, and during adulthood, form strong, linear dominance hierarchies with daughters occupying dominance ranks just below those of their mothers. Adult females develop strong social bonds and display extensive allogrooming and other affiliative behaviour towards one another[19]. Juvenile and adult males, on the other hand, usually emigrate from their natal troops, but bonnet macaque males appear to be unique in being rather unpredictable in this regard, some individuals even staying back to become the most dominant males in their respective natal troops[19]. Adult males form unstable dominance hierarchies through direct aggression and coalitions, and, unusually for most cercopithecines, exhibit extensive affiliative interactions with one another[19].

Our insights into the social knowledge underlying decision-making processes in bonnet macaques come from a three-year study (from 1993 to 1996) on a wild troop (Troop G I) inhabiting dry deciduous scrubland and mixed forests around Bangalore city[10]. During the course of this study, the troop had 44–52 individuals, including 8–11 adult males, 11 adult females and 22–30 juveniles and infants. Data on tactical deception are derived from observations on this troop as well as from a second troop (Troop G II) occupying an adjacent, partially overlapping home range during the same study period. This troop consisted of 30–35 individuals with 5–7 adult males, 10 adult females and 15–20 juveniles and infants. In addition, tactical deception was also studied in a third troop (Troop B I) inhabiting the Bannerghata National Park near Bangalore. This troop, consisting of 3–4 adult males, 6 adult females, 8 subadult males, and 8–14 juveniles and infants, was studied for a period of about 12 months during 1999–2000.

Data on social knowledge and tactical deception were obtained by behavioural observations on all individually identified adult and subadult animals in the respective study troops; each sampling day usually consisted of 10 h of observation, from 0800 to 1800 h (ref. 10). The sampling methods used included focal animal sampling with samples of 15 min duration each on an individual chosen randomly without replacement, and opportunistic sequence sampling of rare behavioural events and social interactions involving more than two individuals[10]. The results reported here are based on approximately 1800 h of observation on the three troops, sampling effort being comparable across all adult and subadult individuals in all these troops.

Social knowledge

An important component of social cognition is the social knowledge that individual primates might possess with regard to certain attributes of other individuals that they regularly interact with within their social group. In addition to the obvious recognition of each animal as a distinct individual, the possible attributes that such knowledge might encompass could include their dominance ranks and affiliative relationships – factors that seem to influence much of the social behaviour observed in primate societies.

A recent study on bonnet macaques documented a frequent interaction between adult females – allogrooming supplants – in which a dominant female displaces one member of a pair of grooming females (see Figure 1), both subordinate to her[10]. In a majority of these observed supplants (~ 80%), the most subordinate of the three individuals left her grooming partner as soon as she noticed the dominant female approaching them – such females were thus clearly aware of their own subordinate status relative to the other two individuals[10]. On about 20% of these occasions, however, it was the other female (the

more dominant of the two allogrooming individuals) that left – and the factor that most significantly appeared to influence this decision was the social attractiveness of her grooming partner, defined in terms of the amount and consistency of allogrooming that this individual received from all the other adult females in the troop[10]. These dominant females thus retreated when their grooming partners, though subordinate in rank, were more socially attractive, receiving relatively higher levels of allogrooming more consistently from all the other adult females in the troop. Bonnet macaque females, therefore, are clearly aware of the social attractiveness of their grooming companions and thus seem to be knowledgeable about the social relationships maintained by the other females in the troop.

That individual females might also know the relative dominance ranks of their troop members was revealed by the typical patterns of aggressive behaviour and allogrooming choices that occurred during other similar triadic interactions. If neither of the two allogrooming subordinate females retreated when the third dominant female approached them, for example, the latter usually displayed aggression towards the more subordinate of the two females[10]. Occasionally, however, she did not display any agonistic behaviour but proceeded to directly allogroom one of the two individuals– and, in the majority of these cases, she groomed the more dominant female[10]. The approaching female thus seemed to be aware of the relative dominance ranks of the two other females, both subordinate to her.

Logistic regression analysis of the decisions made by the females indicated that three factors were taken into consideration when they decided to either remain behind or retreat during allogrooming supplants: knowledge of the subject's own dominance rank, her rank difference with the approaching dominant female and rank difference with her grooming companion[10]. Individuals are thus

clearly aware not only of their own positions in the rank hierarchy, but also that of the other females in the troop. A model which incorporated the absolute dominance ranks of the latter, however, failed to explain the observed behavioural patterns[10]. Knowledge of another individual's dominance rank is, therefore, egotistical in that it seems to be acquired only relative to one's own; a female knows of her rank difference with another female, but does not appear to be aware of the absolute position of her adversary in the rank hierarchy.

The observation that rank difference with the approaching dominant female and that with the grooming companion both influenced the decision-making process indicates that a bonnet macaque's knowledge system is integrative in nature – females are able to simultaneously process information about all their interacting companions and use this knowledge effectively during social interactions. The decisions made in this particular situation were, in reality, even more complex: the intermediate female in a grooming supplant chose to retreat as the approaching individual became relatively more dominant to her, while her grooming companion became comparatively more subordinate (as also more socially attractive).

Mental representation of individual attributes

A noteworthy observation in this study was that individual macaques seem to be knowledgeable about the general social attractiveness of particular females in terms of the allogrooming that they receive from other individuals, rather than remember specific pair-wise affiliative relationships[10]. Since, as mentioned earlier, they also know the relative dominance rank of each adult female in the troop, this seems to constitute a clear example of recognition of individuality and individual attributes by these animals. Furthermore, the decision to retreat or remain behind during allogrooming supplants also depended on the absolute position of the actor in the dominance hierarchy – the more subordinate an individual the more likely she was to retreat[10]. Clearly then, each bonnet macaque female has knowledge of some of her own individual attributes as well.

Although all of these abilities must obviously call for some form of fairly sophisticated mental representation of particular individuals, including themselves, associated with their specific properties, what remains unclear is how exactly such information is categorized and coded for in the non-verbal cognitive architecture of the macaque mind. It is also important to note that during triadic interactions, the integrative property of the bonnet macaque's knowledge system allows her to respond appropriately to the relative dominance ranks of the other interacting individuals. It is striking, therefore, that whatever may be the stored imagery of the individual attributes of the two females she is interacting with, it is

Figure 1. Two adult female bonnet macaques allogrooming. The most common affiliative social interaction displayed by primates, allogrooming not only leads to the cleaning of the hair and removal of ectoparasites, but, more importantly, serves to strengthen social bonds in different situations.

possible for her to access both these sources and integrate them when finally making a socially complex decision.

Attribution of motives and formation of a belief system

Since during allogrooming supplants, the dominant member of the grooming dyad is more likely to retreat if her grooming partner is socially attractive, these females behave as if they 'believe' that the approaching individual is targetting their subordinate, but usually more socially attractive companion. Bonnet macaques thus seem to be capable of attributing motives to other individuals within their social matrix, suggesting that they may be able to develop beliefs about such motives.

It would appear that this decision to retreat was taken on the basis of a belief that a highly socially-attractive individual is more likely, in general, to be the preferred target for affiliative interactions, even if she holds a relatively low position in the dominance hierarchy. That such a belief might indeed be valid is supported by our earlier observation that there was a strong positive correlation between the number of approaches that the subordinate female of the allogrooming dyad received from other females and her social attractiveness[10]. The nature of this belief and the attribution of a corresponding motive to the approaching individual also seem to be rather pragmatic, since bonnet macaque females evaluate social attractiveness of an individual on the basis of the levels of allogrooming received and the consistency with which such grooming is received from other females in the troop.

Projection of experience?

An interesting insight into the nature of this particular belief system comes from the actual choices that the troop females made in their display of aggression and grooming preferences during triadic interactions. Thus, when a grooming supplant did not actually occur, as described above, the approaching individuals were most likely to display aggression and chase away the more subordinate of the two individuals, while on other occasions, if they did not demonstrate any aggression, they almost invariably preferred to groom the more dominant member of the dyad. Why then occasionally did the more dominant member of the allogrooming dyad retreat? One possible answer to this question is that bonnet macaque females may form a general belief system regarding the social attractiveness of the other females in the troop and motives may be attributed to the approaching females during triadic interactions in accordance with such a system.

This belief system may, however, be an erroneous one – and this is revealed by the fact that although the approaching females usually chose the dominant member of the allogrooming dyad as a grooming companion during allogrooming supplants, these same females retreated when they were, in turn, approached while grooming a socially attractive subordinate. In other words, individual females exhibited this erroneous behaviour even though, on several occasions, they themselves had preferentially allogroomed the dominant member of a grooming pair after approaching such dyads.

Could this be considered a failure, in some sense, of macaque females to project their own past experiences, and thus to adopt different, but suitable, behavioural strategies under changing situations? Thus, is it possible that a bonnet macaque female, as the dominant member of a grooming pair, is unable to attribute the correct motive to an approaching individual, although she herself had such a motive earlier as an approaching individual? If this is indeed true, bonnet macaques are similar to rhesus macaques, which were unable to empathize with and understand the motivations of their partners in a laboratory cooperative task, although they themselves had taken up similar roles earlier[17]; as mentioned earlier, successful role-reversal in these experiments was necessarily accompanied by fresh trial-and-error learning.

Tactical deception

Human-like deception requires that an individual who signals information creates a false belief in another individual, the audience. The signaller thus needs to recognize that the mind of the audience can be in a state of knowledge that is different from one's own and that it is possible to alter and hence, control mental states of others without necessarily changing one's own. Such manipulations are usually tactical in that they involve the use of acts from the normal repertoire of the actor in situations where they are likely to be misinterpreted by the audience – leading to some tangible benefit for the actor with or without some corresponding cost to the audience[20,21].

All such acts of tactical deception are thus functional, and most cases of deception documented in primates can be included in this category[21]. But is primate deception truly intentional, attributable to a theory of mind (see ref. 22 for a theoretical discussion)? Does the deceiver actually attempt to alter the beliefs of another individual when it actively suppresses some information or signals false information to the other? Or, has experience simply taught the deceiver the use of certain behavioural strategies in particular situations, leading to predictable responses from the audience and thus allowing the actor to achieve a desired goal?

Mind-reading or behaviour-reading?

A total of 128 events of social interactions that could potentially be considered deceptive was observed in the three study troops of bonnet macaques over the entire

study period, and the overwhelming majority of these provide clear evidence for tactical deception over other competing explanations[23]. It is also noteworthy that although individuals in all the troops exhibited comparable levels of deception overall (ranging from an average of 0.0025 to 0.0060 acts/h/individual in the three troops), the troops differed widely with regard to the social situations – competition for food, mates and grooming partners, as well as aggressive interactions (see Figure 2) – during which tactical deception was displayed (Figure 3). There were also striking differences in the distribution of deceptive acts across the 15 categories of deception commonly used by individuals in each of these troops (Figure 4).

A striking feature of the deception displayed by bonnet macaques is the remarkable individual variation in the performance of these acts[23]. Certain individuals thus exhibited deceptive acts with very high frequency at levels

Figure 2. Concealment by ignoring—a form of simple tactical deception. Victims of aggression often exhibit different types of displacement behaviour; this adult male perfunctorily chews on a dry twig as he ignores his aggressor sitting close by and thus conceals any expression of nervousness or fear.

significantly greater than that shown by other individuals within the troop; moreover, such deceptive abilities appeared to be independent of age categories and dominance ranks of the actors. The fact that certain individuals are more adept at deception than others, and that the ability to deceive is independent of other individual attributes, including age, is an indication that many of these acts could involve mentalism on the part of the actor rather than simple behaviour analysis (since the latter would usually imply that rates of deception would increase with age and/or experience). It could, of course, be true that these particular individuals are good social learners and, therefore, more efficient behaviour analysts. This, however, seems unlikely since it would require complex behavioural contingencies (given the type of situations where tactical deception is actually shown) to occur with high probabilities for individuals to learn such associations successfully; such contingencies appeared to be relatively rare in the social sphere of the study troops (pers. obs.).

If, on the one hand, macaques are indeed better social learners than mentalists while, on the other, complex social situations where deceptive behaviour could potentially be learnt are rare, it might be predicted that individuals who exhibit high levels of deception should perform the same acts repeatedly. However, for the deception displayed by males in all the study troops, there was significant positive correlation between the frequency of deceptive acts and the functional categories to which these acts belonged (Figure 5); in other words, individuals who deceived at relatively higher levels, did so in many more different ways. This is an indication that these individuals may have indeed been better cheaters, with perhaps greater insights into the power of manipulative behaviour than other individuals in the same troop. A particularly illuminating example comes from Troop B I in which nine out of the 16 acts of deception observed among the eight
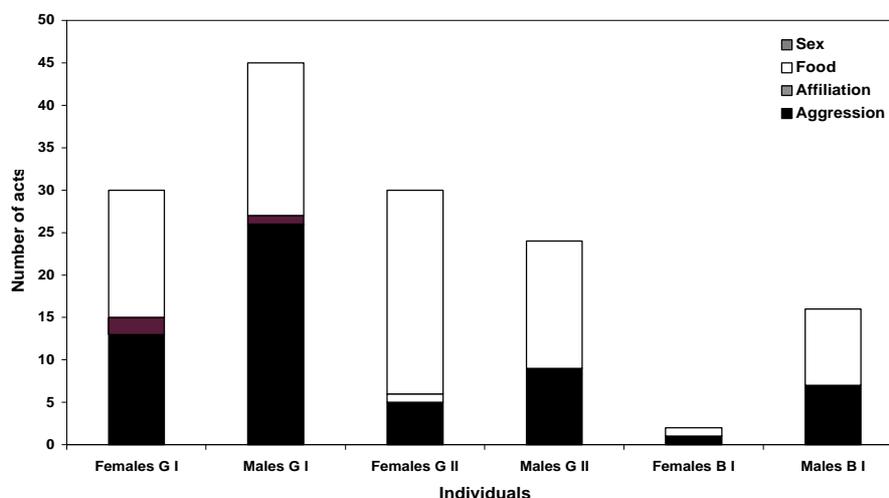

Figure 3. Tactical deception displayed by male and female bonnet macaques in the Troops G I, G II and B I during different social situations – competition for mates (sex), food (food) and allogrooming partners (affiliation), and agonistic interactions (aggression).

resident males were performed within a period of eight months by a single young subadult male who had recently joined the troop; remarkably, these nine acts belonged to nine different categories of deception!

Moreover, certain rare acts of tactical deception displayed by the study individuals were extremely complex and involved several simple categories of deceptive acts juxtaposed together and performed in rapid succession to achieve one particular desired goal (Categories of deception X–XIV in Figure 4). The probability that these individuals had experienced an earlier identical behavioural contingency for them to learn all the constituent decep-

tive acts is indeed very low; moreover, virtually all these complex, deceptive, behavioural sequences were performed only on a single occasion each during the entire study period.

If the argument put forward regarding the involvement of the mind in at least some of the acts of tactical deception displayed by bonnet macaques can be accepted, it would seem logical that such manipulation must necessarily involve at least second-order intentionality. This would mean, in simple terms, that an individual performs a deceptive act in order to change the belief system of the audience – and then takes advantage of the false belief,
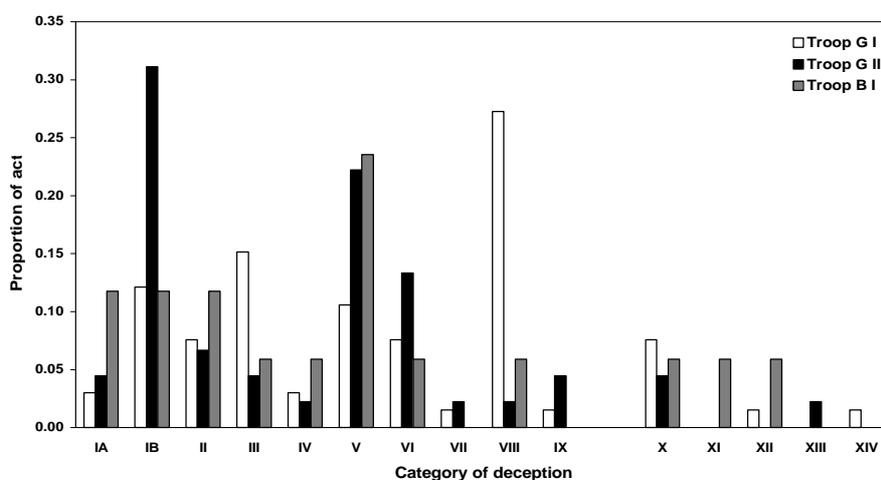
Figure 4. Distribution of deceptive acts across different categories of tactical deception exhibited by Troops G I, G II and B I. Categories of deception are: Simple – IA, Concealment by hiding behind a physical barrier; IB, Concealment by hiding away from the troop; II, Concealment by inhibiting interest in object; III, Concealment by ignoring; IV, Distraction by calling; V, Distraction by threat; VI, Distraction by close-range behaviour; VII, Creating a neutral image; VIII, Creating a positive image; IX, Deflection to third party; and Complex – X, Concealment by hiding behind a physical barrier and concealment by inhibiting interest in object; XI, Concealment by inhibiting interest in object and distraction by close-range behaviour; XII, Distraction by leading and distraction by calling; XIII, Distraction by threat and distraction by close-range behaviour; XIV, Concealment by hiding behind a physical barrier, distraction by close-range behaviour and distraction by threat.
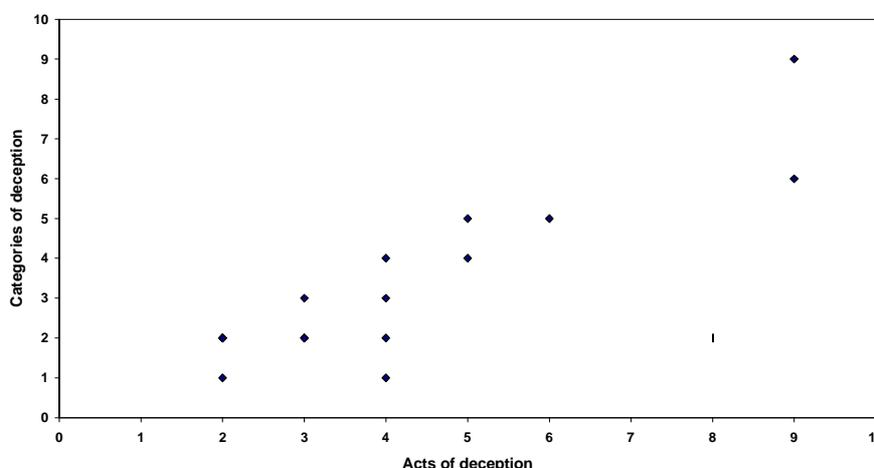
Figure 5. Correlation between the number of deceptive acts and the number of categories of tactical deception in which they were performed by males in the three study troops. Each point represents a single individual. Kendall's rank correlation: $t = 0.6352$, $n = 17$, $P < 0.001$.

which has been generated, to achieve a particular personal goal.

Visual perspective-taking

Several events of deception by three individuals in two different troops involved acts of physical concealment (see Figure 4) in which the actor either simply hid from the target behind some physical object or performed a behaviour surreptitiously behind a barrier, occasionally leaning out to inspect whether the target individual was still present. Since all these individuals repeatedly performed this exercise – in different contexts and using different objects or barriers to hide behind – these acts would appear to represent a genuine tactic and were possibly not simply events coincident by chance alone.

This kind of visual perspective-taking, estimating what would be visible from another individual's point of view, has earlier been seen in other primates, notably chimpanzees and baboons[20]. Such an ability to recognize and utilize the geometric perspective of another individual has been equated to being able to represent correctly another individual's mental representation in one's own mind, although there have also been dissenting views on such an identity (see ref. 24 for a detailed discussion).

'Intention to deceive' as an intervening variable?

Another characteristic feature of the tactical deception exhibited by bonnet macaques was that individuals did not invariably use deceptive strategies in apparently identical situations, a result not expected if these acts were being performed in response to certain behavioural contingencies alone. What is difficult to rule out, of course, is that there were subtle differences in these apparently identical situations – and these may have triggered-off the deceptive acts in some of them, but not in others.

A related finding to this form of volitional control of deception was that of some individual adult males who changed their repertoire of deceptive acts following changes in the social environment. This happened when two particular males emigrated out of one troop and joined a neighbouring one; following this movement, they displayed very different categories of deceptive acts and one of them even exhibited a five-fold increase in the frequency of his deception. A major difference that these individuals faced in the two situations was that of their dominance ranks, which fell drastically once they had joined the new troop. It is, therefore, entirely possible that the perception of their specific positions in the rank hierarchy in the respective troops as well as the changing demands of the new social milieu may have triggered on a completely different repertoire as well as increased rates of deceptive acts in these two males.

It is perhaps possible to model a complex set of stimulus–response links in the different social situations outlined above, leading to differential responses in terms of the deceptive acts displayed by specific individuals. It might, however, be more parsimonious to consider 'intention to deceive' as an intervening variable in these different situations, as outlined by Whiten[13]. This would mean that a variety of perceptual changes under different social conditions would be translated into either the presence or absence of potentially deceptive acts or into different forms of deceptive acts, all of these mediated by an intention or lack thereof to deceive. In addition to simplifying a possibly complex web of conditional stimulus–response chains, such an intervening variable would also be compatible with the notion of second-order intentionality underlying deception, outlined above.

An incomplete theory of mind?

Subordinate adult bonnet macaque males often give out loud predator alarm calls when they are chased by more dominant males – even if there are no predators in the vicinity. An extremely intriguing variant of this deceptive act was observed in one of the study troops. A victim of aggression emitted a false predator alarm call on being chased, but continued to give this call even as he descended from the tree and continued to walk on the ground – behaviour that would never have been performed if there was truly a predator around (see also ref. 1 for a comparable incident).

Deceiving individuals thus occasionally exhibit behavioural components that are not compatible with their own apparent 'belief' system, as communicated to others. An important point here is that notwithstanding its incompleteness, such a belief system must have been generated to alter the belief state of the audience – a return to second- order intentionality. What is also noteworthy is that the aggressor did not appear to have read the internal inconsistency of the victim's deceptive act; this may have been due to his own theory of mind being similarly incomplete[1].

Summary

Cercopithecine or Old World monkey societies are typically characterized by social relationships established between individuals belonging to different age cohorts, dominance ranks and kinship groups. Given the unique nature of every relationship that individuals need to develop and maintain, it is perhaps not surprising that bonnet macaques may be inherently capable of solving many complex social problems. These monkeys may, for example, observe the social interactions of other individuals in the troop and acquire knowledge of different attributes of these individuals, thus aiding their own decision-making during social interactions. Many individuals are also potentially capable of developing strategies of tactical deception; these strategies not only encompass different categories of deceptive acts but are also employed in a variety of social situations, including agonistic interac-

tions and competition over food, allogrooming companions and sexual partners.

Underlying these complex social strategies may be the ability of individual macaques to form rudimentary mental representations of their social interactants and their various attributes, including their relative dominance ranks and social attractiveness. Interestingly, an elaborate example of tool manufacture and use by a bonnet macaque, documented earlier, indicated the possibility that the individual was able to perceive the underlying causality of its actions and also form a mental model of the tool to which it could repeatedly refer[25]. The cognitive ability to form mental representations could thus underlie the bonnet macaque's interactions with both the mechanical as well as the social components of its immediate environment.

Analyses of the decision-making processes that bonnet macaques employ during social interactions indicate that individuals appear to attribute distinct motives to other individuals, a clear example of second-order intentionality. Moreover, several acts of tactical deception provide evidence that the macaques are capable of attributing visual perspectives to another individual, thus being able to perceive what would be visible from that particular individual's point of view. This arguably constitutes another way in which a monkey is able to comprehend another monkey's mental representation of the world – again a prime cognitive candidate for second-order intentionality.

Bonnet macaques, it can be argued, may thus have some degree of comprehension of the mental world of other individuals and are able to attribute distinct individuality to each other, including themselves. But does this imply that they have a theory of mind? It has been discussed above that during social interactions, individuals may fail to project their own experiences onto others, and are thus often unable to correctly predict the true motives of other individuals. Moreover, even in instances of tactical deception where the macaques communicate their apparent 'beliefs' to others, they exhibit behavioural components incompatible with their own beliefs. Extensive observational investigations on the study troops have also so far failed to turn up any clear evidence for unambiguous third-order intentionality, which could be considered evidence for a true theory of mind. In conclusion, therefore, even if bonnet macaques do have a rudimentary theory of mind, it is a construct incomplete in many ways, some of which have been outlined here and some that still remain to be discovered.

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