'MINDREADING' MAMMALS? ATTRIBUTION OF BELIEF TASKS WITH DOLPHINS

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Abstract   *Animal Welfare 2001, 10:* S119-127

'Mindreading' or theory of mind (ToM) refers to the capacity to attribute mental states to others. This ability is regarded as a critical component of what has, to date, exclusively characterized the advanced social cognition displayed by humans. The false belief task is a key test for ToM in different animal species. On a standard non-verbal false belief task, humans pass from age 4, whereas non-human primates consistently fail. Neuroanatomical and behavioural evidence for dolphins, however, indicates that they are capable of passing ToM tasks. The current paper represents a synthesis of the relevant dolphin research on neocortical evolution and non-invasive behavioural tests of precursors for ToM and the attribution of beliefs. The success of dolphins on attribution of belief tasks, in the absence of learning or cueing, indicates that they are capable of 'mindreading'. What are the implications of animal 'mindreading'? ToM tasks probe for reflexive consciousness and, by this criterion, dolphins may display reflexive consciousness. The implication of this conclusion is that future behavioural studies of social cognition will have considerable ethical and legal implications for animal welfare.

Keywords: *animal welfare, dolphin, mental state attribution*

Introduction

Since being suggested by Premack and Woodruff (1978), the concept of a theory of mind (ToM) has been pervasive in the literature on cognitive development. ToM, or 'mindreading', was initially defined as being the capacity to attribute or 'impute' mental states to one's self and others, such as 'purpose or intention, as well as knowledge, belief, thinking, doubt, guessing, pretending, liking, and so forth' (Premack & Woodruff 1978 p 515). Children appear to have developed the requisite cognitive skills for a fully emerged ToM (ie joint attention, pretence, attribution of desire, knowledge state and, finally, beliefs) by age 5 (Call & Tomasello 1999). Chimpanzees, *Pan troglodytes*, on the contrary, do not appear to display such attributional states (Premack 1988), specifically those concerning beliefs (Call & Tomasello 1999, but see also O'Connell [1995]). The false belief task is regarded as the key test for ToM (Wimmer & Perner 1983; Baron-Cohen *et al* 1985). The capacity for attributing false belief depends on 2nd order intentionality, or forming a mental representation of the mental representation of another individual (Leslie 1987). The attribution of beliefs and their functional significance form the focus of this paper, as the relevance of intentional representations and beliefs to cognitive functioning and consciousness have been noted elsewhere (Dennett 1978; Rosenthal 1993).

'Mindreading' and its relevance

Certain aspects of social cognition that fall under the umbrella term ToM are considered to be of vital importance for understanding the evolution of advanced social cognitive capacities. Why? The intense social nature of primate cognition, based on 'the unique nature of primate groups' (Dunbar 1993) is thought to distinguish it from general mammalian cognition (Tomasello & Call 1997). Individuals living in sophisticated primate societies may gain an adaptive benefit by socially manipulating or 'outwitting' their conspecifics (Byrne & Whiten 1988), sometimes by forming coalitions and alliances (Harcourt 1992). Within this framework, human cognition is set apart from that of non-human primates on the basis of certain 'special' complex cognitive qualities, the most notable being the ability to predict the behaviour of others and regulate one's own behaviour according to the attribution of beliefs (Call & Tomasello 1999).

This status quo is backed up by neuroanatomical data in relation to behavioural ecology variables (see Dunbar [1995]) and is also supported by a multitude of anecdotal evidence from fieldwork studies (see Cheney & Seyfarth [1990]; Byrne & Whiten [1990]). Of importance, from an empirical perspective, is that behavioural experiments into primate social cognition indicate that non-human primates do not succeed at certain critical tasks that humans are capable of (see Povinelli *et al* [1994, 1997]; Call & Tomasello [1999]). This serves to reinforce the notion that human cognitive evolution is discontinuous from that of other animals on the basis of social intelligence (see Povinelli [1993]). The conception of qualitative mental difference not only informs our conception of ourselves and our 'human nature', but also influences the nature of our interaction with other animal species and impacts on their welfare.

Behavioural tasks investigating 'mindreading' in primates

Within the spectrum of research into ToM, the false belief task has come to represent the keystone of whether or not an animal possesses this capacity. This position has been advanced from the literature describing the ontogeny of ToM in humans. Here, children first appear to show comprehension of joint attention, where behavioural procedures coordinate attention between the child and its social partner in order to permit a shared awareness of objects of events (Mundy & Sigman 1989). Such behaviours include protodeclarative pointing, where pointing is used to establish joint attention on an object (Tager-Flusberg 1989). This can be distinguished from protoimperative pointing, which is merely requestive in nature and, as such, devoid of declarative representation (Mundy *et al* 1994). This pointing is followed by the 'halfway-house' of pretence or pretend play (Leslie 1987) and, finally, the understanding of unobservable mental states, such as desire, followed by belief (Wellman & Bartsch 1994). If the attribution of belief states is the most fully developed expression of ToM in humans (see Dennett [1978]), it might be understandable why it has been considered as the benchmark test for ToM in other animals.

The situation has not, however, been so clear-cut concerning non-human primates. While Povinelli and Eddy (1996) demonstrated that chimpanzees were capable of joint attention, it was subsequently suggested that they might not comprehend the communicative nature of such processes (see Povinelli *et al* [1997], Tomasello *et al* [1997]). Attempts to prove comprehension of knowledge by chimpanzees (Povinelli *et al* 1990) have proved unsuccessful (Povinelli 1994), following criticisms that there were inadequate controls for learning (Heyes 1993). Call and Tomasello (1999) have also shown that chimpanzees do not pass a task designed to test the attribution of false beliefs.

The finding that humans comprehend the knowledge and belief states of others, while chimpanzees do not, appears to draw support for those who advocate a theory of qualitative shift in attributional capacity. According to this implicit scale of 'mindreading', great apes may show precursors to the ToM capacities of humans and, likewise, monkeys may show precursors to the capacities of the apes. Consider, as an example, that chimpanzees appear capable of role reversal or perspective-taking (Povinelli *et al* 1992a), while macaques, *Macaca mulatta*, do not display this capacity (Povinelli *et al* 1992b). One must, however, remain sceptical of the notion of discontinuous evolution. This is especially the case as adequate consideration has not yet been given to the possibility of mentalizing in other cognitively complex, non-primate species.

Potential confounds: evidence from relative brain size and behavioural research

The above theory is based on a potentially spurious assumption: as certain cognitive capacities are not manifested in the behaviour of our closest extant relatives (including chimpanzees, orang-utans [*Pongo pygmaeus*] and gorillas [*Gorilla gorilla*]), they are assumed to have evolved in our recent (human) evolutionary past (see Call & Tomasello [1999]). Evolutionary theory, however, supports the notion that genetically unrelated species might evolve similar characteristics, according to the process of convergent evolution. Furthermore, the theory of evolution proposes that capacities are gradually accumulated over time, representing quantitative and not qualitative change (Darwin 1859).

In the light of the potential inadequacies that may inform our understanding of animal cognition, this paper aims to address why it may be necessary to consider comparative brain-behavioural evidence. This shall be illustrated with reference to comparative neuroanatomical and behavioural ecology data, before discussing a compendium of social cognition experiments with dolphins.

Relative brain size and its correlates in mammals

Several authors have found that high relative brain size indices in primates correlate with variables representative of social complexity (Sawaguchi & Kudo 1990; Dunbar 1992). The argument, paraphrased, is that animals living in larger or more complex social groups are more likely to engage in social interaction and hence in heightened social manipulation (Humphrey 1976). The increase in social strategizing places an increased cognitive load on the individual, the carrying of which, according to Byrne (1995), requires enlarged areas of the brain, such as the neocortex.

Dunbar (1992) recognized the importance of the neocortex and devised the neocortex ratio, ie the neocortex volume relative to the rest of the brain. He proposed that it was only for the more recent anthropoid primates (monkeys, apes and humans) that enlarged neocortices were predictive of social group size. This relationship did not hold for the older, prosimian primates (lemurs, lorises and tarsiers) or insectivores. Accordingly, it was proposed that the selection pressure for the enlargement of the neocortex arose with later-evolving social complexity and hence was only present in the more recent primates (Dunbar 1995).

The uniqueness of the neocortex-group size relationship for primates was brought into question by pilot data for dolphins, indicating that several dolphin species had large neocortex ratios that appeared to be related to social group size (Tschudin *et al* 1996). Following this, it was confirmed that the neocortex ratio was indeed predictive of social

group size for other mammals, such as carnivores and some insectivore species (Dunbar & Bever 1998).

More recently, Tschudin (1999) has confirmed that dolphins appear to have neocortex ratios that lie between human and non-human primates and that these ratios lie closer to humans than to chimpanzees. Furthermore, relative brain size has been shown to correlate with sociality in dolphins, both for the neocortex ratio and social group size (Tschudin 1999) as well as for the Encephalization Quotient (brain size relative to body size) and pod (group) size (Marino 1996).

The substantial enlargement of the dolphin neocortex and its predictive relationship to social group size led to the suggestion that advanced social cognition might not be such an evolutionarily recent primate phenomenon, but rather that it may also be evident in dolphins (Tschudin 1999). This appears to be supported by literature documenting the complexity of dolphin sociality, communication and cognition (Connor *et al* 1992, 1999; Morrel-Samuels & Herman 1993; Herman *et al* 1994; Marten & Psarakos 1995; Pack & Herman 1995; Xitco & Roitblat 1996). One way of empirically testing such a hypothesis was to run a series of behavioural experiments with captive bottlenose dolphins (*Tursiops truncatus*), in order to investigate their capacity for social cognition.

A plausible evolutionary alternative? Social cognition in dolphins

In keeping with the sequential trend described for primate ToM research, the first experiments to be run with dolphins were aimed at investigating joint attention, as the initial precursor to ToM. Captive bottlenose dolphins were tested for whether or not they could understand signs that were communicative in nature and which had not been previously trained or explicitly used. The signs were fused to a trained gestural command 'fetch object' and comprised either gazing directly at, pointing at or holding up a replica of one of two objects in the water. The dolphins showed that they could use pointing (see also Herman *et al* [1999]) and directed gaze to discriminate between objects; in addition, two subjects demonstrated that they could use a replica of the object to locate it (Tschudin *et al* in press). This is of interest, as non-human primates tested under comparable conditions cannot interpret such signs spontaneously (Tomasello *et al* 1997).

Following the finding that dolphins were capable of joint attention, we wished to probe whether or not they could demonstrate sensitivity to the knowledge state of another, considered an essential precursor to ToM. We adapted the procedure of O'Neill (1996) documented for young children. The task was composed of two conditions. We recorded the behaviour of the dolphin when the trainer was either ignorant of – or knowledgeable of – the location of a fish that the experimenter had baited in one of two boxes. Preliminary analysis indicated that dolphins gesture and vocalize more emphatically when a trainer is ignorant of the location of a baited reward than when she is knowledgeable of its location (Tschudin unpublished data).

The performance of dolphins in the above tasks suggested that they were promising candidates for the crucial ToM test, the false belief task (FBT). We used a modified version of Call and Tomasello's (1999) non-verbal FBT with captive bottlenose dolphins at Sea World, Durban, South Africa. During training, each dolphin learnt to associate a tap signal (from a human communicator) on one of two boxes with the location of a fish reward. Dolphins indicated their response by swimming towards or orientating towards the desired box. After completing the training phase, each dolphin engaged in a series of pre-test control trials. These trials assessed whether or not the dolphin was capable of tracking the visible

displacement of the fish (the fish is visibly moved from one box to the other) or the invisible displacement of the fish (the boxes are switched and hence the fish is invisibly moved) and, crucially, whether or not it could ignore the communicator when it knew her to be misinformed (Tschudin *et al* unpublished data).

Following successful performance on training and pre-test trials, each animal participated in a series of false belief trials. During these trials (in the presence of a human communicator and behind a screen to occlude the dolphin's view), a human baiter baited one of two boxes – that the dolphin knew were present from prior viewing – with a fish reward. The screen was removed and the communicator departed from the experimental area. While the communicator was out of sight, the baiter switched the boxes in full view of the dolphin. Upon returning, the communicator tapped the box that she (falsely) believed to contain the fish. On all of these test trials, all dolphins chose the box at the location that the communicator did not tap. To check that the dolphins were not solving the task using cueing or other means such as sonar, we ran a series of post-controls, where the dolphins did not perform above chance (Tschudin *et al* unpublished data).

We did not, however, control adequately for the possibility of reversal or discriminative learning in the above test trials and hence we ran an additional test, where we interspersed false belief trials with true belief trials. On these trials, the presenter of the reward was blind as to the ordering of the trials and to the location of the reward. The procedure was the same, save that on true belief trials, the boxes were not switched while the communicator was absent, but only upon her return. Both animals that passed the initial training chose the box that the communicator indicated on true belief trials and chose the box not indicated by her on false belief trials. Both animals passed false belief – and true belief – tasks on first trial in this test and all four animals passed on first trial in the previous test. It appears that the animals are attributing a mental state of false belief to the communicator and using her (mis)information to solve the task (Tschudin *et al* unpublished data). We cannot, however, dismiss the alternative possibilities of one-trial learning and/or inadvertent cueing. Until future experimental designs address these issues, we have to remain cautious of the current findings. If, however, dolphins *are* solving the FBT in the absence of any detectable learning or cueing, they are demonstrating the mental state attribution of false and true beliefs. The FBT is considered to be the benchmark of ToM and hence, by definition, dolphins would appear to be capable of 'mindreading'.

A way forward: implications for the study of consciousness and cognition

Within the context of comparative cognition, if we entertain the possibility of mammals 'mindreading' (theorizing about the mental states, such as beliefs, of other individuals), we are bound to consider what implications may lie ahead for the study of consciousness and for animal welfare. Baars (1988) suggested that in order to address consciousness we require 'some reasonable conception of self', which he refers to as the 'self-system' or the framework of knowledge surrounding conscious experience. The 'self-system' is regulated by the beliefs that pertain to it – by the conceptual knowledge of self (Baars 1988; Neisser 1988; Marcel 1994). Hence, the importance of the concept of 'belief' for understanding consciousness and higher-order psychological functioning (Dennett 1978; Tye 1995).

Aspects of such conceptual knowledge of self, however, only appear to arise during social development with the advent of shared attention, and result in reflexive self-consciousness (Neisser 1993). Reflexive consciousness differs from non-reflexive consciousness

(phenomenal or subjective experience), as it incorporates both an awareness of phenomenal experience and an awareness of self (Marcel 1994).

If the capacity for reflexive self-consciousness is partially contingent upon the interpersonal context of development, then the capacity to 'mindread' appears to be an expression of reflexive consciousness. In this light, if dolphins are mentalizing, they may be demonstrating reflexive consciousness. This is supported by giving consideration to the relationship between intentional representation and consciousness. Rosenthal (1993) has expressly related intentionality to consciousness. Dolphins appear to be demonstrating higher-order intentionality in ToM tasks, which indicates the capacity for reflexive consciousness. Thus, conscious intentional thought may not be uniquely human, as has been previously proposed (Davies & Humphreys 1993).

It has been argued that using the comparative method allows us to begin to understand the evolution of consciousness and cognition and the functional significance thereof (Dawkins 1993; Tschudin et al 1999). This is not to suggest that a floodgate of reflexive consciousness opened up to a multitude of animal species over evolutionary time. The most likely contenders are animals with well-developed brains (possessing relatively large neocortices, perhaps), to facilitate higher-order psychological functioning. Yet brains are energetically expensive to maintain and perhaps the benefit of greater mental representation may only outweigh its cost in socially complex animals (see Humphrey [1976]). Complex processes, such as language, may not be necessary to explain the evolution of mental representation, especially if non-human animals are demonstrating non-verbal representation. Alternatively, language and culture may have arisen to facilitate the adaptive benefit of the social transfer of mental representations. Our humble knowledge regarding the evolution of mental representation in other animals, and the extent to which this may have arisen, indicates an urgent need for wider (albeit more cautious) research into animal brain-behaviour relationships.

Animal welfare implications

The interpersonal context of social development is considered to be necessary for the expression of reflexive consciousness (Neisser 1993). Furthermore, Vygotsky (1978) argued that 'mind' cannot be detached from its social context, which is critical to the emergence of cognition during individual development. In view of this, we may be able to use tasks that investigate social cognition to simultaneously explore aspects of reflexive consciousness in non-human animals. If an animal displays the capacity for reflexive consciousness, then it must be capable of non-reflexive consciousness. While this approach allows us to reconstruct the evolution of consciousness, it does not indicate that animals which do not display reflexive consciousness are not aware of their phenomenal experience (non-reflexive consciousness). Animal 'mindreading' and consciousness may be more pervasive than previously recognized. What are the implications for animal welfare? Clearly, there is a critical need for further research. In the interim, the ethics and legislation that strive to ensure the welfare and protection of animals need to be formulated with the consideration that some animals may be capable of reflexive consciousness, as well as possessing an intentional understanding of others. This is especially applicable to invasive experimentation and hunting. We might all benefit from paying more attention to animal minds, establishing what they are capable of theorizing about and, finally, minimizing psychological harm to them.

Acknowledgements

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