

A Bonnet Macaque is perched on the edge of a dark, craggy rock formation. The background is a vast, hazy landscape of rolling hills and mountains under a soft, overcast sky. The lighting is diffused, suggesting an early morning or late afternoon setting. The monkey is looking towards the right of the frame.

# The Monkey's New Mind!

*Cognitive Networks in Bonnet Macaques*

Anindya “Rana” Sinha

National Institute of Advanced Studies, Bangalore

Centre for Neuroscience, Indian Institute of Science, Bangalore



## **The importance of studying the primate mind**

- What is it like to be a monkey?
  - How did we come to be what we are today?
  - Can we understand more fully how the primate brain works?
-

---

# Distributed Cognition

- Communicative interactions as directly observable cognitive events rather than using behaviour to infer invisible mental events such as intentions
  - Embedding of cognition within the social interactions of primates and its manifestation through the behavioural coordination of interacting individuals
  - Useful approach for modeling developmental and evolutionary processes, including development of phenotypic flexibility, social learning and the appearance of social traditions through behavioural transmission
  - Primate cognitive evolution as manifested through changes in context-sensitivity and multi-tasking of individuals in social contexts as well as the coordination of social attention to each other
  - Does not necessarily preclude the appearance of mental representation capabilities of individuals in some contexts and later stages of cognitive evolution
-



# The Primate Mind

- Has social complexity progressively evolved in primates?
- Has social complexity selected for enhanced cognitive abilities?
- Can certain higher cognitive attributes be defined functionally in non-verbalising primates?
- What could be the behavioural correlates of specific higher cognitive processes in wild primates?
- Are primates capable of reasoning and abstract thought in the absence of a complex language?
- Are primates perceptually and reflectively conscious?



# The Primate Mind

- Has social complexity progressively evolved in primates?
- Has social complexity selected for enhanced cognitive abilities?
- Can certain higher cognitive attributes be defined functionally in non-verbalising primates?
- What could be the behavioural correlates of specific higher cognitive processes in wild primates?
- Are primates capable of reasoning and abstract thought in the absence of a complex language?
- Are primates perceptually and reflectively conscious?



# A Theory of Mind

Many primates know and predict one another's behaviour...

...are they as knowledgeable about one another's beliefs, emotions and intentions?

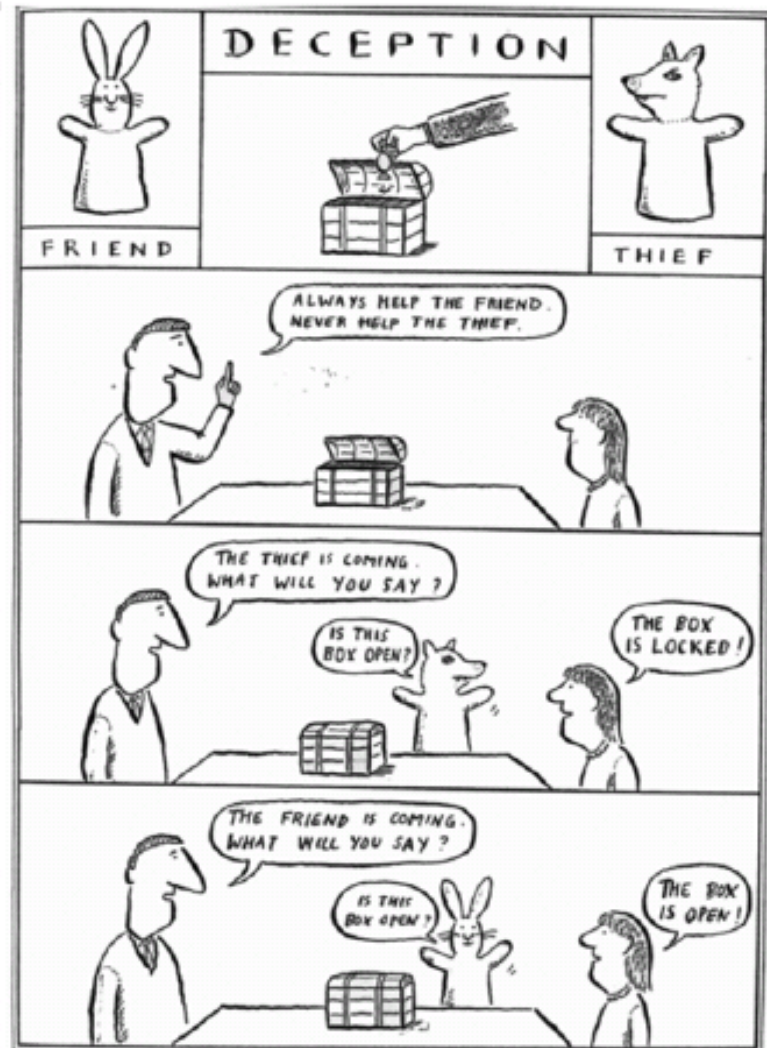
**Theory of Mind, *Premack and Woodruff 1978***

The ability to attribute beliefs, knowledge and emotions to both oneself and others

Recognition of specific mental states in oneself and in others

---

# A Theory of Mind



**Reading behaviour or reading minds?**

Prediction of behaviour versus prediction of motives or beliefs

Trial-and-error mechanisms versus knowledge-based systems

---





# Social Cognition in Bonnet Macaques

**Cognitive mechanisms underlying complex social processes – attribution of mental states?**

- Social knowledge
- Tactical deception



- Habituation of troops, identification of individuals and systematic observation of behavioural interactions
- Observations spanned 10 hours on each sampling day (0800 - 1800 h)
- Focal animal sampling of 15 minutes duration on an individual chosen randomly
- Opportunistic sequence sampling
- Data based on 600 h of observation; focal animal sampling of  $24.5 \pm 2.8$  h on the 11 adult females of the troop
- Statistical analyses of the behavioural data



## Social Interactions and Individual Decisions

Female A approaches two allogrooming females B and C, both subordinate to her; either B or C retreats even before A can reach them

Out of many such observed events, the more subordinate member of the grooming dyad, C, retreats in c. 85% instances; B retreats only in c. 15% cases

**Subordinate females generally prefer to avoid two higher-ranking individuals during allogrooming supplants**

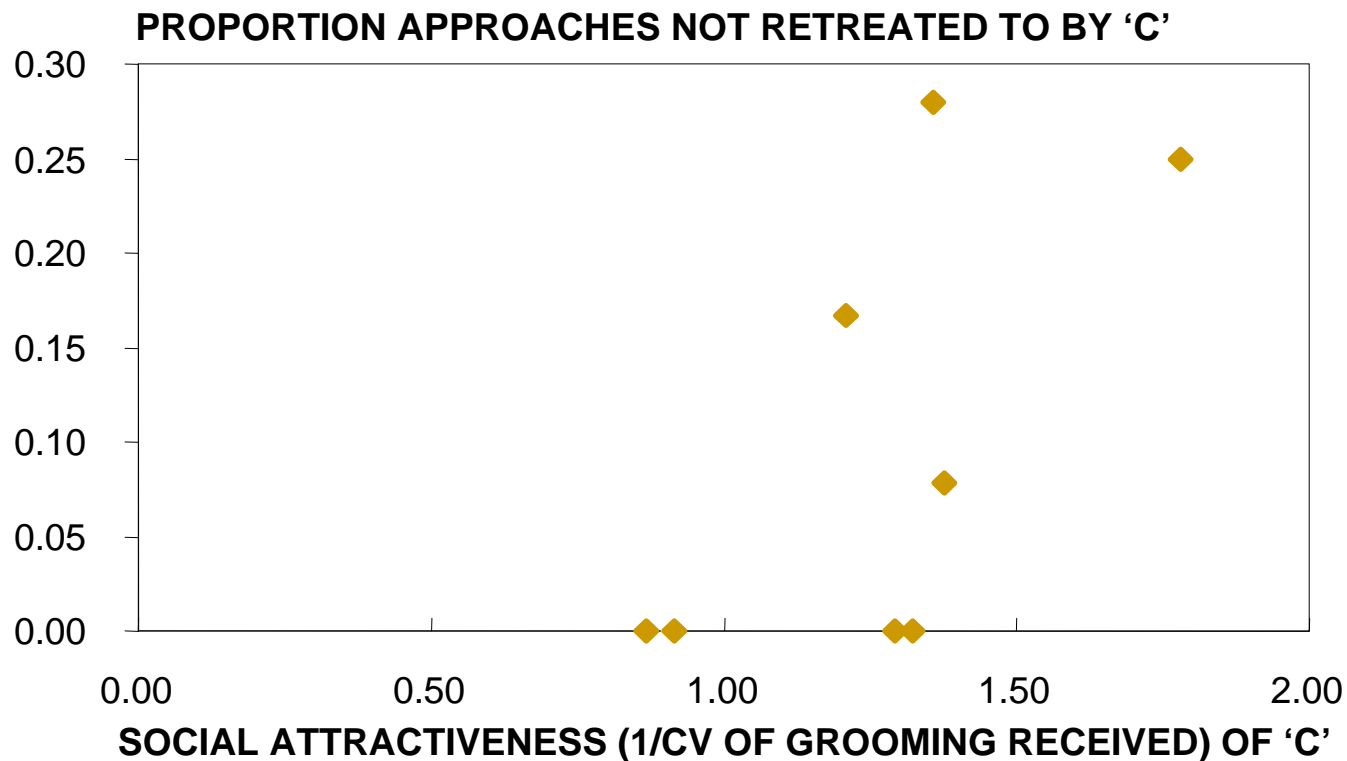
Why then did the dominant member of the grooming dyad retreat in the exceptional instances?

---



## Knowledge of Allogrooming Relationships

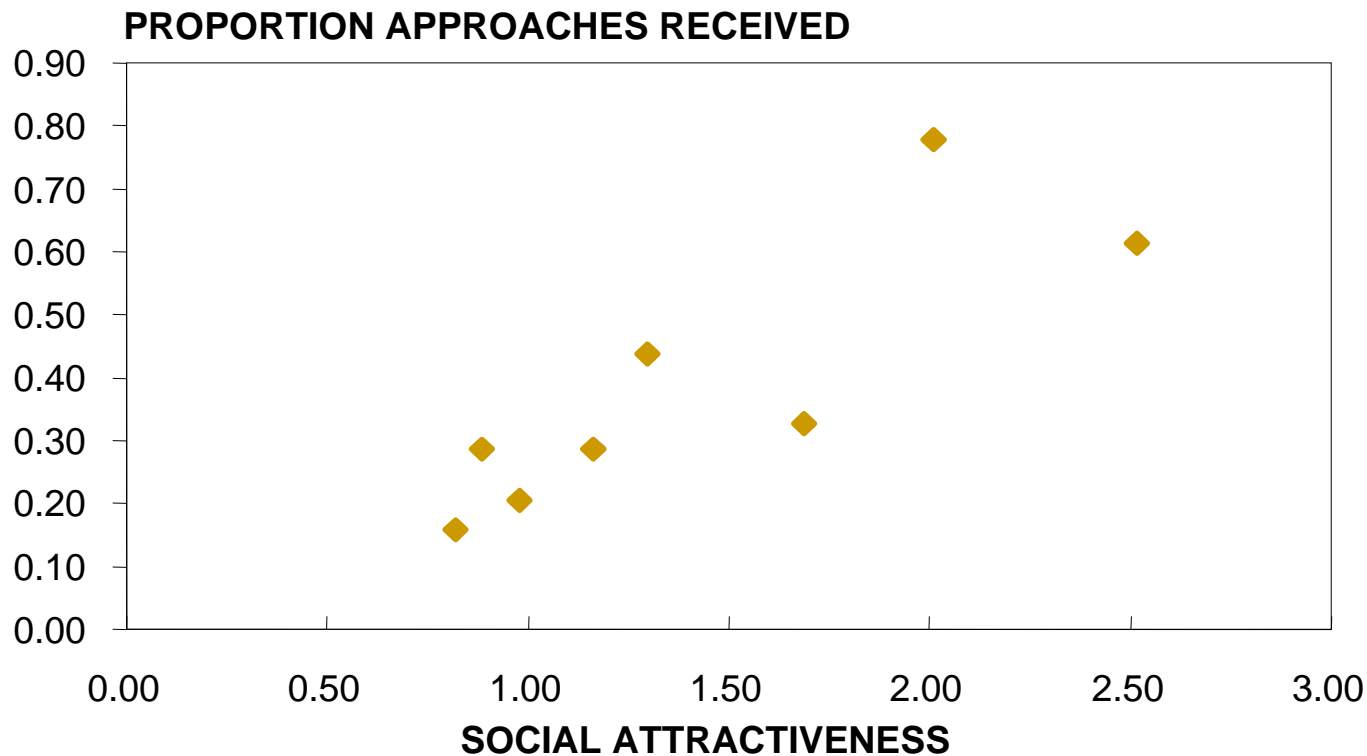
- Dominant individuals ('B') tended to retreat more when their subordinate companions ('C') were more socially attractive in terms of the grooming that they received from other troop members





## Knowledge of Dominance Ranks I

- A significant positive correlation between the social attractiveness of an individual and the number of times she was approached by others only when she was the dominant member of the dyad





## Knowledge of Dominance Ranks II

- The approaching females preferentially allogroomed the more dominant member of the dyad
- When aggression was displayed by the approaching females, it was more often directed towards the subordinate members of the dyad



# Logistic Regression Analysis I

## Dependent variable

- Probability of retreat by any individual female

## Independent variables

- The individual's own dominance rank
- Rank of the approaching dominant female, or rank difference with the approaching female
- Rank of the allogrooming companion, or rank difference with the allogrooming companion
- The individual's own social attractiveness
- Difference in attractiveness with the allogrooming companion

---

## Logistic Regression Analysis II

The probability that the dominant member of a dyad would retreat when approached by a third individual increased simultaneously with

- The individual's own decreasing dominance rank
- Decreasing rank difference with the approaching individual
- Increasing rank difference with the subordinate member of the dyad

The probability of her retreat did not, however, depend on

- The absolute dominance ranks of the other two individuals
  - The social attractiveness of either member of the dyad
-





# Social Knowledge I

- Bonnet macaque females appear to know their own dominance ranks and those of other females relative to their own positions in the rank hierarchy

**Knowledge is egotistical**

- During interactions with multiple individuals, social decisions are made on the basis of integrated information

**Knowledge is integrative**

- Individuals know the social attractiveness of other females, but this knowledge seems to be utilised in terms of its correlation with that of dominance ranks

**Is knowledge hierarchical?**



## Social Knowledge II

- Individual macaques appear to be aware of the social attractiveness of other individuals, rather than remember specific pair-wise affiliative relationships
- Individuals are knowledgeable about their own position in the dominance hierarchy and the relative dominance ranks of the other troop members

**Abstraction and mental representation of personal attributes  
and those of other individuals**



# The Primate Mind

- Has social complexity progressively evolved in primates?
- Has social complexity selected for enhanced cognitive abilities?
- Can certain higher cognitive attributes be defined functionally in non-verbalising primates?
- What could be the behavioural correlates of specific higher cognitive processes in wild primates?
- Are primates capable of reasoning and abstract thought in the absence of a complex language?
- Are primates perceptually and reflectively conscious?



# The Primate Mind

- Has social complexity progressively evolved in primates?
  - Has social complexity selected for enhanced cognitive abilities?
  - Can certain higher cognitive attributes be defined functionally in non-verbalising primates?
  - What could be the behavioural correlates of specific higher cognitive processes in wild primates?
  - Are primates capable of reasoning and abstract thought in the absence of a complex language?
  - Are primates perceptually and reflectively conscious?
-

## **The Intentional Stance, *Dennett 1983-1988***

A theoretical framework to investigate attribution of mental states

Intentional phenomena refer to specific mental states including beliefs, desires or emotions

### **Different levels of intentionality**

Zero-order: no beliefs or desires at all; instinctive behaviour

First-order: the subject has beliefs, but no beliefs about other individuals' beliefs

Higher-orders: some conception about their own and other individuals' states of mind

‘Be what you would seem to be’

– or, if you’d like it put more simply –

‘Never imagine yourself not to be otherwise than what it might appear to others that what you were or might have been was not otherwise than what you had been would have appeared to them to be otherwise.’

Lewis Carroll

*Alice’s Adventures in Wonderland, 1865*



---

# Intentionality and Attribution

## Higher order intentionality requires...

- the ability to represent, simultaneously, two different states of the mind – those of the actor and of the audience
- the ability to recognise a discrepancy between the intentional states held by the two minds

## Simultaneous recognition of different mental states

- Attribution of knowledge in children
  - Autism in children and adults
-

## **Human-like deception requires...**

- the actor to create a false belief in the mind of the audience
- the actor to recognise that the audience's mental state can be altered without changing one's own

## **Tactical deception in primates requires...**

- use of an act from the normal repertoire of the actor in a situation where it is likely to be misinterpreted by the audience
- the actor to benefit from the use of such a tactic

**Can some of these acts of tactical deception be genuinely intentional in that the actor truly attempts to alter the mental state of the audience?**

---

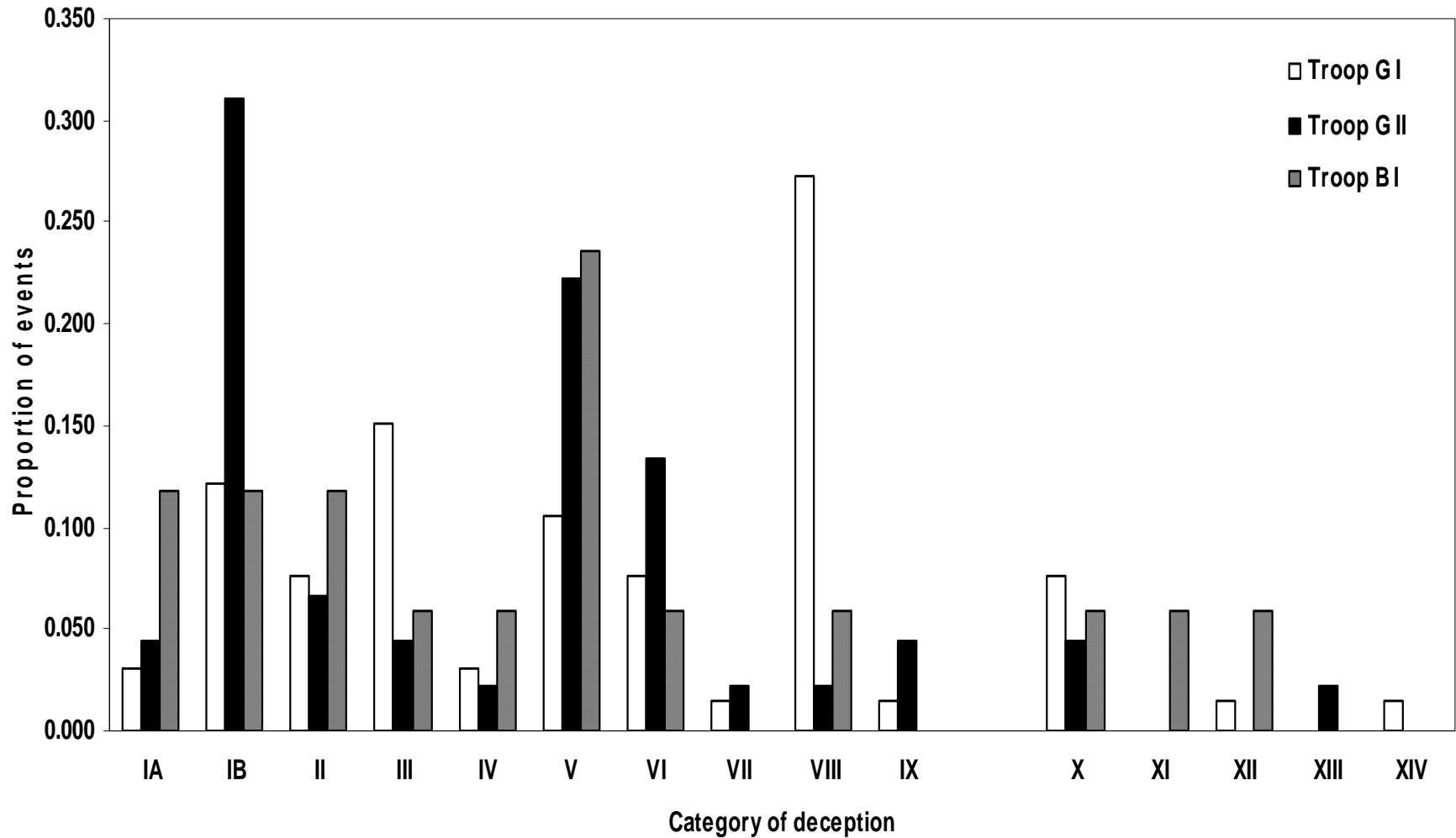




## Categories of Deception: Simple

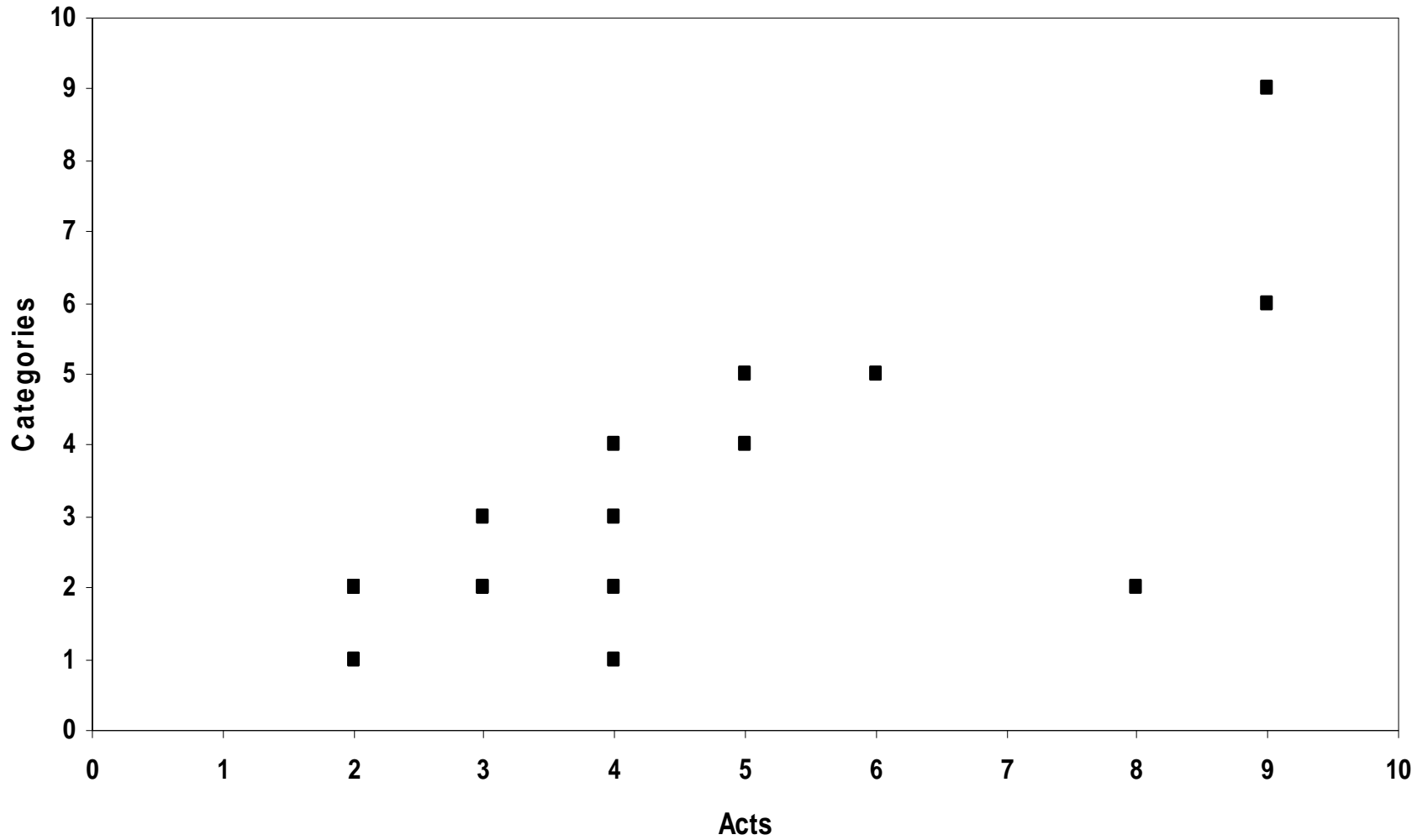
- Concealment
  - by hiding - behind a physical barrier
  - by hiding - away from the group
  - by inhibiting interest in object
  - by ignoring
- Distraction
  - by calling
  - by threat
  - by close-range behaviour
- Creating an image
  - neutral
  - affiliative
- Deflection to third party

# Categories of Deception: Troops





# Categories and Events: Males





## Intentionality in Deception I

- Individual males and females who exhibited high levels of deception deceived in many different categories
- Several young and otherwise 'inexperienced' individuals displayed complex deception involving a number of acts in different categories performed in quick succession
- Individuals did not invariably use deceptive strategies in apparently identical situations
- Some males changed their repertoire of deceptive acts following changes in the social environment

**Mind-reading more parsimonious than behaviour-reading**



## Intentionality in Deception II

- Several events of deception by different individuals involved acts of physical concealment

### **Recognition of the visual perspective of others**

- Deceiving individuals occasionally exhibit behavioural components that are not compatible with their apparent 'belief' system

### **An incomplete theory of mind...**





# Distributed Cognition in Social Networks

Use of innate social dominance rules in combination with individually-acquired learning of dominance ranks and affiliative relationships by female bonnet macaques while taking social decisions

Distributed cognition in bonnet macaques leads to extensive behavioural coordination and a system of phenotypic flexibility in social strategies by using a combination of innate rules with open systems of individual and social learning

These represent partly competing, partly mutually-supporting mechanisms that selection tunes to specific patterns of environmental variation within the niches of particular species

Sinha 1998, 2003, 2005





# The Macaque Mind

- Bonnet macaques are inherently capable of solving complex social problems, for example, through tactical deception
- Individual macaques may be able to form rudimentary mental representations: of themselves, of their social companions and of specific tools
- Interacting macaques appear to attribute motives to other individuals and exhibit visual perspective-taking
- Individuals may, however, fail to project their own experiences to other contexts
- Even if bonnet macaques have a rudimentary hypothesis of mind, it is perhaps an incomplete construct
- Bonnet macaques exhibit remarkable flexibility in individual behavioural strategies; they thus possess specific social learning and appropriate distributed cognitive abilities that may have promoted the establishment of independent social traditions across different groups and populations



**Anirban Datta-Roy  
Niranjan Joshi  
Kakoli Mukhopadhyay**

**National Centre for Biological Sciences, Bangalore  
National Institute of Advanced Studies, Bangalore  
University of Agricultural Sciences, Bangalore**

