

**PS452**  
**Intelligent Behaviour**

**Lecture 10: Animal Theory  
of Mind and Deception**

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# Part 3: Intelligent Behaviour in Animals

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*Complex interactions with objects*
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# Part 3: Intelligent Behaviour in Animals

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*Mindless signals or deliberate acts*
  - Natural communication
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*In search of proto-modules*
  - Animal (lack of) awareness of other minds
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# Lecture 10: Animal Theory of Mind & Deception

- **10.1 Theory of Mind: A Tool for Deception**
  - Theory of Mind and modularity
  - Evidence for Theory of Mind in animals
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# Lecture 10: Animal Theory of Mind & Deception

- **10.4 The Origins of General Intelligence?**
- **10.5 Animal, Human, and Machine Intelligence**

# 10.1 Theory of Mind: A Tool for Deception

- Theory of Mind: A popular concept in child psychology
  - The assumption that other beings are intentional systems and have mental states, including:

Knowledge

Beliefs

Desires

Goals

# 10.1 Theory of Mind: A Tool for Deception

- Theory of Mind investigated using false-belief paradigms

- *Sally-Ann task*

Sally has a marble

Sally puts the marble in a basket

Sally goes away

Ann hides the marble in a box

Sally returns

Where will Sally look for the marble?

▶ Young children ✘: in the box

Older children ✓ in the basket

➡ Those who cannot perform the task do not fully understand about beliefs and knowledge in others

# 10.1 Theory of Mind: A Tool for Deception

- Human deception *often* influences beliefs
  - Must believe that beliefs exist in order to intend to change them
  - Must infer exact beliefs and have goal-state of desired beliefs
- ➔ 2nd Order Intentionality
- ➔ Theory of Mind = deceiver's toolkit, understanding about beliefs necessary to manipulate them deliberately
- ➔ Lack of ToM concepts/understanding makes deception far harder
- ➔ Deception by animals might indicate at least some Theory of Mind concepts/understanding?

# Theory of Mind and Modularity

- Humans are social animals
  - Material advantages to individuals who can take advantage of this
    - Persuade other people to co-operate without reciprocating
    - Obtain benefits, e.g. resources, by deceiving/cheating
  - Material advantages to individuals who are less susceptible to being taken advantage of
    - Need to spot deceit/cheating by others
    - Recognise potential cheaters from past experience

# Theory of Mind and Modularity

- Cosmides
  - Cheater-spotting skills vital for long-term survival, otherwise person will be stripped of time and resources
  - ➔ Too dangerous to leave this to learning
  - ▶ Complex logical reasoning ability is engaged strongly for tasks phrased in a cheater-detection context
  - ➔ Cheater-detection skills are uniquely strong, processes underlying them are modular; genetically programmed
- Baron-Cohen
  - ▶ Autists have problems unique to this domain
  - ➔ Might be owing to a defective *Theory of Mind module*

# Theory of Mind and Modularity

- Roberts (2007)
  - Cosmides' *contextual facilitation methodology* just as suspect here as for other research
  - ➔ Logic effects within domains are unexplained, implying general cognitive capacity is important for such tasks
- Happaney & Zelazo (2007)
  - False-belief tasks in autism research are more logically demanding than baseline inference tasks
  - ➔ Autism performance with false-belief tasks is because ToM problem solving is just difficult rather than modular

# Theory of Mind and Modularity

- Moses & Sabbagh (2007)
  - Beliefs are invisible, intangible, abstract:
    - Reasoning about them demanding of cognitive capacity
    - Learning about ToM concepts requires sustained learning
  - ➔ Human high cognitive capacity is focused towards ToM concepts, resulting in ToM expertise, a *virtual module*
- Expertise at this difficult-yet-usefully-predictive concept raises cognitive power beyond basic cognitive capacity
- ➔ Focus on ToM concepts and consequent learning and understanding gives *cognitive fringe-benefits* (cf. language)

# Theory of Mind and Modularity

- To what extent are human Theory of Mind reasoning abilities a product of genetically programmed modularity?
  - ➔ Answer has implications for animal intelligent behaviour
  - ➔ Animal ToM status has implications for human ToM
- Byrne & Whiten (1988)
  - Social animal group-members are potential tools that could be used to achieve goals
    - ➔ Some sort of high-level intelligence needed for the most effective control of such complex 'devices'?

# Theory of Mind and Modularity

- Reznikova (2007)
  - Many animals have complex interactions and a stable social hierarchy, both exploitable
    - Cooperation
    - Alliances
    - Vendettas
  
    - Kinship
    - Recognition on non-kin
    - Intelligent recruitment
  
    - Communication
  - High cognitive demands, difficult to achieve, deadly to fail?

# Theory of Mind and Modularity

- Argument for a genetically programmed *Theory of Mind module* in animals (as well as humans)
  - Social sensitivity/manipulation is just as vital for any social animals as for humans
  - Full human ToM unlikely, but any genetic tendency to form a proto-ToM module = a huge head start
- Prediction
  - ➔ Likelihood/sophistication of specialised ToM module will be correlated with complexity of animal social lives
  - ➔ Sophisticated social behaviour by such animals not intelligent by a cognitive capacity definition

# Theory of Mind and Modularity

- Argument against a genetically programmed *Theory of Mind module* in animals (as well as humans)
  - Lack of evidence for specialist genetically programmed module in humans strongly points to same in animals
  - Theory of Mind thinking difficult but learnable with sufficient cognitive capacity and sustained learning
- Prediction
  - ➔ General cognitive capacity will predict ability to 'solve' social problems
  - ➔ ToM problem solving = another intelligence test

# Evidence for Theory of Mind in Animals

- Whiten & Byrne (1988)
  - To what extent are primates [etc.] *natural psychologists*
  - Are they *mind readers* in the sense that they can infer or manipulate beliefs of others?
- See Byrne (1995), Pearce (2008), Reznikova (2007)

# Evidence for Theory of Mind in Animals

- Seyfarth & Cheney (2003):
  - No trace of sufficient intentionality for Theory of Mind concepts/understanding in vervet monkey alarm calls
  - Only chimpanzees might display any ToM concepts/understanding
- **BUT** Chimpanzees (and dogs, etc.) skilled at making inferences from observing gaze direction
  - ✓ Follow gaze to find ***what X is thinking***
  - ✗ Follow gaze to find ***something interesting***
  - Necessary to rule out non-Theory of Mind explanations

# Evidence for Theory of Mind in Animals

- Vonck & Povinelli (2006)
  - How effectively can chimpanzees respond to differences in human knowledge?
- Task 1, Phase 1
  - Trainer A hid food under one of several cups behind a screen
  - Trainer B (absent during hiding) arrived
  - Cups revealed
  - Trainer A and Trainer B pointed to one cup each
- ▶ Chimpanzees ***eventually*** learnt to select cup pointed to by Trainer A, the trainer with cup-location knowledge

# Evidence for Theory of Mind in Animals

- Vonck & Povinelli (2006) *cont.*
  - Task 1, Phase 2
    - Trainer C hid food under one of several cups behind a screen
    - Trainer A observed hiding
    - Trainer B wore a bucket, could not observe hiding  
*[chimpanzees familiar with buckets]*
    - Cups revealed
    - Trainer A and Trainer B pointed to one cup each
  - ▶ Two chimpanzees immediately correct, selecting cup pointed to by Trainer A
  - ▶ One chimpanzee ***eventually*** correct, one failed to learn

# Evidence for Theory of Mind in Animals

- Vonck & Povinelli (2006) *cont.*
  - Task 2 (*postscript task*)
    - Chimpanzees taught to use natural begging gesture to obtain food from trainers
    - Trainers with food rewards either wore or did not wear buckets
  - ▶ Chimpanzees used begging gesture even on non-seeing trainers
  - ▶ Eventually learnt not to beg for food, probably using a face visibility cue

# Evidence for Theory of Mind in Animals

- Vonck & Povinelli (2006) data: major pattern is reminiscent of learning tasks in general
  - Phase 1: Gradual improvement
  - Phase 2: Considerable individual differences in success
- ➔ Essential genetically programmed *proto-ToM module* should not display widespread individual differences
- ➔ Learning should not be slow, whole point of *Theory of Mind module* is that it enables fast, effortless responses

# Evidence for Theory of Mind in Animals

- Vonck & Povinelli (2006) data: major pattern is reminiscent of learning tasks in general *cont.*
- ➔ Implies a difficult learning task at the limits of chimpanzee cognitive capacity/learning ability
  - Specifically, the *Learning Set* task
    - Phase 1: chimpanzees learnt that certain types of trainer more useful than others?
    - Phase 2: knowledge generalised to a new situation (or not)
- ➔ For *proto-ToM* module evidence, would need **better** performance at *social* than *abstract* learning task versions
- ➔ Performance exactly in line with cognitive capacity, **not** the complexity of chimpanzee social lives

# Evidence for Theory of Mind in Animals

- Chimpanzees in Vonck & Povinelli (2006) were too young (5/6 yrs)?
  - Older chimpanzees better, but likely that they have learnt the usefulness of human eye visibility (see Pearce, 2008)
    - ✓ Trainers with visible eyes ***know something***
    - ✗ Trainers with visible eyes ***are useful***
- ➔ No need to invoke Theory of Mind concepts

# Evidence for Theory of Mind in Animals

- Tomasello *et al.* (2003) Chimpanzees only infer Theory of Mind concepts for other chimpanzees?
  - Scenario 1
    - Dominant and Subordinate chimpanzees both observed food being hidden in view of each other, then released
    - Subordinate chimpanzee did not take food
  - Scenario 2
    - Subordinate chimpanzee observed food being hidden without dominant chimpanzee present
    - Subordinate chimpanzee did take food
- ➔ Subordinate chimpanzee understood knowledge of dominant chimpanzee?

# Evidence for Theory of Mind in Animals

- Povinelli & Vonck (2003)
  - Tomasello *et al.* (2003) findings can be explained by applying a simple rule learnt from past experience
    - Don't go after visible food if the Dominant is also visible***
  - No need for Theory of Mind conceptual amendment
    - ~~because the Dominant has seen it and knows where it is~~***
- ➔ No special ToM capability or potential in chimpanzees
- ➔ Chimpanzees 'know' that group members might be useful or dangerous, but not their mental states

# 10.2 The Special Case of Deception

- Whiten and Byrne (1988)

- Deceptive acts are ...

*“acts from the normal repertoire of an individual used at low frequency and in contexts different from those in which it uses the high frequency (honest) version of the act, such that another familiar individual is likely to misinterpret what the acts signify to the advantage of the actor”*

	Correct Context	Incorrect Context
Behavior X Frequency	Frequent	Rare
Reward for Behaviour X	Neutral	High

# 10.2 The Special Case of Deception

- In groups of co-operating individuals, deception and deception spotting skills may be particularly beneficial
  - More offspring (genes) are passed on for
    - Members who deceive to obtain benefits, who are tactical and avoid getting caught
    - Members who spot deceivers, recognise them, and punish them in future
  - Evolutionary arms race eventually yields skilled processing of mental states and motives?
- ➔ Look for evidence of attempts at deception as a precursor to sophisticated Theory of Mind concepts/understanding?

# Deception in the Wild

- Widespread, but much of it cannot be labelled *intelligent*
- Deception in the Wild (***cognitively trivial***)
  - Camouflage and physical mimicry (morphological deception) is usually out of control of the animal
    - But coloured moths take advantage of colouring by ***landing*** on appropriate surfaces (Partridge, 1978)
- Deception in the Wild (***low interest***)
  - Accidental emissions of incorrect signals that are strongly rewarded, forming simple learnt associations
  - Single, universal, species-specific behaviours that can be accounted for by evolution

# Deception in the Wild

- Deception in the Wild (*high interest*)
  - Evidence of intent and or strategic planning required: deliberate wrong signals to animal's advantage
  - For intentional behaviour, what is the objective?
    - Change behaviour of target: 1st Order Intentionality
    - Change beliefs of target: 2nd Order Intentionality

# Deception in the Wild

- Mimicry by fireflies
  - Many species of fireflies, each with unique light patterns
    - Within a species, males will have a distinctive mating pattern, females will have a distinctive response
    - *Photenus* species preyed upon by *Photuris* firefly
      - Male *Photenus* emits mating pattern
      - Female *Photuris* mimics the reception response of the *Photenus* female
      - Male *Photenus* approaches female *Photuris* and is eaten
- ➔ Female mimicry very unlikely to be intentional
- ➔ Likewise male detection of mimicry on approach

# Deception in the Wild

- Marler *et al.* (1986): Food-calling by chickens
  - Cockerels who discover food emit a courtship call
    - Edible food
      - Never call if **only** other males present
      - Sometimes call if no others present
      - Always call if females present
    - Inedible food
      - May call (less strongly) if unfamiliar females present
- ➔ Deception is evidence of intention and communication in chickens?

# Deception in the Wild

- ➔ Claims of Marler *et al.* (1986) are too strong, simple additive threshold model explains likelihood of calling

Threshold for calling = 10 units

Others Present	Edible Food (+10)	Inedible Food (0)
Only males (-5)	<b>X</b> (+5)	<b>X</b> (-5)
No others (0)	<b>✓</b> (+10)	<b>X</b> (0)
Familiar females (+5)	<b>✓</b> (+15)	<b>X</b> (+5)
Unfamiliar females (+10)	<b>✓</b> (+20)	<b>✓</b> (+10)

# Deception in the Wild

- Munn (1986): Alarm calls by birds
  - Investigated mixed-species flocks of tropical birds feeding on insects under forest canopy
    - Some serve as sentinels (e.g. warn of hawks)
    - Sentinels feed on insects flushed out by others
    - Scope for alarm call misuse
  - ▶ Sentinels known to give alarm calls when no predators present, false alarm calls?
    - Other birds scatter, sentinels collect food
    - Likely if feeding young or several birds chasing same insect
- ➔ Observational evidence insufficient to show that this is more than learnt associations

# Deception in the Wild

- Ristau (1991): Injury feigning by sandpiper
  - Sandpiper nests/incubates eggs at ground level
  - Often disturbed by ground-based predators
    - Will sometimes leave nest, dragging a wing
    - Leads predator away from the nest
    - After reaching a safe distance, leaves predator, flies back to the nest
    - Sensitive to gaze direction, more likely to engage if predator gazing at the nest
- ➔ Impressive, vervet monkey calls don't show gaze-effects
- ➔ Could be 2nd Order Intentionality, but is also a single species-specific behaviour

# Deception in the Wild

- Overall: Non-primate deception
  - Most behaviour limited to one particular act in one particular situation (c.f. tool use)
  - Deceptive behaviour possible without clear requirement for intentionality
- ➔ Caution necessary when interpreting primate behaviour

# Primate Deception in the Wild

- Hyman (1989)
    - Fundamental contradiction from researchers
      - Deception central to chimpanzee social life but ...
      - Actual instances of deception are rare
  - Byrne & Whiten (1987, 1988, 1991);  
Whiten & Byrne (1988):
    - Why is this the case?
      - Expert deceiving species also expert deception spotters?
      - Animals can recognise each other?
- ➔ Results in no more deception than for other animals

# Primate Deception in the Wild

- Whiten & Byrne (1988), Byrne (1995)
  - Tactical deception in primates: flexible, effective acts that vary according to context
  - Questionnaires sent to many primate researchers to gather deception anecdotes
  - ▶ Five categories of deception identified

# Primate Deception in the Wild

## (1) Concealment

- *Agent conceals information or object from Target*
  - Not making a sound signal,
  - Not gazing at a desirable object
- ▶ Baboons sometimes observed to turn backs on others when holding food
- ➔ ***1+ Order Intentionality***  
Awareness of what others can see
- ➔ ***Zero Order Intentionality***  
Learned response from previous food loss

# Primate Deception in the Wild

## (2) Distraction

- *Agent diverts Target's attention away from situation*
  - Looking away, leading away
  - Inappropriate vocalisation
- ▶ Baboon pursued by others, suddenly stood on hind legs scanning distance, others broke off chase, searching for predators, none detected by human researchers
- ➔ ***1+ Order Intentionality***  
Intention to trigger searching behaviour
- ➔ ***Zero Order Intentionality***  
Inappropriate (lucky) behaviour triggered by anxiety

# Primate Deception in the Wild

## (3) Creating an Image

- *Agent misrepresents own status to Target*
- ▶ Chimpanzee injured in a fight walked with a limp **only** in presence of attacker
- ➔ ***2+ Order Intentionality***  
Intention to change beliefs of attacker
- ➔ ***Zero Order Intentionality***  
Associated attacker with pain

# Primate Deception in the Wild

## (4) Manipulation of Target by Engaging Social Tool

- *Agent affects Target behaviour by recruiting Bystander*
- ▶ Adult baboon (Target) was digging up food  
Juvenile (Agent) watching Target suddenly screamed  
Second adult (Bystander) chased Target away  
Juvenile (Agent) remained to eat food

### ➡ ***1+ Order Intentionality***

Intention to create chasing behaviour

### ➡ ***Zero Order Intentionality***

Inappropriate (lucky) behaviour triggered by frustration

# Primate Deception in the Wild

## (5) Manipulation of Target by Diversion to Fall Guy

- *Agent affects Target by displacing it to Bystander*
- ▶ Adult male macaque (Agent) was eating  
Dominant male (Target) approached  
Agent attacked and chased nearby female (Bystander)  
Dominant male (Target) continued chase, exiting  
Adult male (Agent) resumed eating

### ➔ ***1+ Order Intentionality***

Intention to create chasing behaviour

### ➔ ***Zero Order Intentionality***

Anxiety caused by expected loss of food displaced to weaker bystander

# Primate Deception in the Wild

- **Counter-Deception (too rare to be given a category)**
  - ▶ Subordinate chimpanzee (Agent) found bananas in box  
Dominant chimpanzee (Counter-Agent) approached  
Subordinate (Agent) shut box and walked away waiting  
for Dominant (Counter-Agent) to leave  
Subordinate (Agent) opened box, took bananas  
Dominant (Counter-Agent), emerged from hiding place  
(behind tree) took bananas
  - ➔ ***2+ Order Intentionality***  
Counter-Agent intended Agent to believe his exit
  - ➔ ***Zero Order Intentionality***  
Counter-Agent learned from experience that he was  
more likely to see/obtain food when behind trees

# Primate Deception in the Wild

- Whiten & Byrne (1988), Byrne (1995) *cont.*
  - ▶ Some primates (e.g. lemurs) have no reported acts
    - Surprising; even birds show deception
    - Researchers not expecting to see deception, so do not interpret behaviour in this way
  - ▶ Chimpanzees: widest range of behaviour, exceed gorillas
    - Chimpanzees have superior ToM resources for deception?
    - Gorillas less competitive, live as close family groups?

# Primate Deception in the Wild

- Whiten & Byrne (1988), Byrne (1995) *cont.*
  - ▶ **BUT** (4) and (5) not reported for chimpanzees
    - Insufficient ToM resources for more complex deceptions
    - Sufficient ToM resources to avoid duping
  - ▶ Chimpanzee researchers most likely to reject learning/behaviourism as explanation for observations
    - Chimpanzee behaviour the most elaborate?
    - Chimpanzees attract certain types of researcher?

# Primate Deception in the Wild

- Whiten & Byrne (1988), Byrne (1995) evaluation
  - Deceptions are taking place by definition
- ➔ But observations/anecdotes are not evidence for (widespread) strategic intentionality
  - Massive scope for selective attention and interpretation biases by researchers
  - No base rates for uninteresting accidents
- ➔ Lack of evidence for Theory of Mind concepts/ understanding forces cautious interpretations
- ➔ Interesting stories and tantalising glimpses at best

# Deception in the Laboratory

- Woodruff & Premack (1979)
  - Phase 1:  
Can chimpanzees be taught to deceive selectively?
    - Food concealed in one of two boxes in view of, but out of reach from, chimpanzee
    - One of TWO trainers, dressed differently, entered the room and chose a box
    - Chimpanzee given opportunity to influence trainer decision
      - **Cooperative trainer** gave food to chimpanzee if chose correctly, otherwise chimpanzee got nothing
      - **Competitive trainer** kept food if chose correctly, chimpanzee received food if trainer was incorrect

# Deception in the Laboratory

- Woodruff & Premack (1979) *cont.*
  - ***Cooperative trainer***
    - ▶ Immediate better than 50% success for all four chimpanzees
    - ➔ Chimpanzees can easily transmit positive information (e.g., gaze direction and pointing), but unintentional

# Deception in the Laboratory

- Woodruff & Premack (1979) *cont.*
  - ***Competitive trainer***
    - ▶ Better than 50% success to begin with, but took longer to make decisions
    - ▶ Eventually declined to chance performance
    - ➔ Suppressing gaze difficult for apes, and considerable individual differences in achievement of voluntary control
    - ▶ For two chimpanzees, trainer success eventually fell to below 50%
    - ➔ Some chimpanzees learnt to give misleading cues (pointing to incorrect container, misusing gaze)

# Deception in the Laboratory

- Woodruff & Premack (1979) *cont.*
  - Phase 2:  
Can chimpanzees selectively act on deception?
    - Food concealed in one of two boxes out of view of chimpanzee
    - One trainer entered the room and pointed to a box
      - **Cooperative trainer** pointed to **correct box**, chimpanzee given the food if selected this
      - **Competitive trainer** pointed to **incorrect box**, chimpanzee not given the food if selected this
    - ▶ All four learnt to choose box cued by **cooperative trainer**
    - ▶ Three of the four chimpanzees **eventually** learnt to reject cues of **competitive trainer**, strong individual differences

# Deception in the Laboratory

- Woodruff & Premack (1979) *cont.*
  - ▶ Chimpanzees learnt to give misleading cues (and ignore misleading ones)
  - ➔ Intentional communication (1st Order)?
- **Evaluation:** Has a special skill really been learnt/displayed?
  - ▶ Slow learning with individual differences in success is in line with chimpanzee learning of logical relationships
  - ➔ No evidence for special Theory of Mind concepts/understanding or potential for these

# Deception in the Laboratory

- Evaluation *cont.*
- Apes were less than five years old when the study ended
- ➔ Humans need time to learn skills of deception, chimpanzee potential underestimated?
  
- Mitchell & Anderson (1997): Capuchins can learn these tasks, with a similar pattern of findings
- ➔ Special, or any, ToM understanding even less likely to be required as an explanation for chimpanzee data

# Return of the Crows

- De Kort *et al.* (2007)
  - Various species of corvids cache food, but other members of the social group may raid the caches
  - Individual differences in raiding tendency
  - Many factors influence caching behaviour in order to minimise raiding
    - Behaviour modified in response to status of observers
    - Behaviour modified in as a result of experience
    - Behaviour modified as a result of own tendencies

# Return of the Crows

- De Kort *et al.* (2007) *cont.*
  - If a known raiding bird is visible to the caching bird
    - Caching delayed until raiding bird is distracted/departs
    - Caching diverted to locations behind obstacles
    - False caches created
  - Caching behaviour is modified according to the gaze direction of the raiding bird
    - Caching distantly if observed, nearby if not
    - Re-caching if observed
  - Raided birds become more selective in location choice
  - Birds which raid are more strategic than non-raiders
    - If observed, more likely to re-cache than non-raiders
    - Will raid if neutral bird observing, not if by the caching bird

# Return of the Crows

- De Kort *et al.* (2007) *cont.*
  - Observation of competitive foraging behaviour
    - Many boxes, food concealed in some of these
    - Some regions had a higher probability of food in boxes
  - ▶ **Subordinate** raven modified foraging strategically
    - **Dominant** raven initially followed **Subordinate**, taking food whenever it was discovered
    - **Subordinate** changed to opening boxes in low reward zone
    - Pursuing the **Subordinate** became inefficient method of obtaining food, **Dominant** raven foraged for itself instead
- ➔ Corvid social behaviour no less strategic than primates
- ➔ As expected from performance at other learning tasks

# 10.3 Evaluation: Theory of Mind & Deception

- Chimpanzees display little evidence for Theory of Mind concepts/understanding when investigated directly
- Investigations of deception capabilities yield little evidence of any special Theory of Mind capabilities germinating
- ➔ Would expect better evidence if complex society necessitated the evolution of a *proto-ToM module*

# 10.3 Evaluation: Theory of Mind & Deception

- Performance of chimpanzees/corvids/other animals exactly in line with other findings:  
Learning, tool use, problem solving, communication
- ➔ ToM thinking and deception = elaborate/difficult learning tasks, not special domains which social animals excel at
- ➔ ***Understanding of Theory of Mind concepts, and deception ability, related to cognitive capacity, not social complexity***

# 10.3 Evaluation: Theory of Mind & Deception

- Chimpanzees are nature's original psychopaths

Human meets unfamiliar human:

***Who are you?***

Chimpanzee meets unfamiliar chimpanzee:

***How are you useful to me?***

- ➔ Cognitive capacity focused towards conceptualising social group members as useful tools to achieve goals
- ➔ ***Cognitive capacity is not focused towards ToM concepts, lack of 'interest' in these makes them harder to learn***

# 10.3 Evaluation: Theory of Mind & Deception

- No evidence for special ToM concepts/understanding, or deception performance even in social animals
- ➔ Human ToM is not 'modular', consequence of high, focused cognitive capacity
- ➔ Humans develop *Theory of Mind expertise*, a virtual module
- Easier to reason about what we can name
- Humans can express/discuss abstract Theory of Mind concepts such as beliefs and desires
- ➔ Versatile language also important for ToM development

# 10.3 Evaluation: Theory of Mind & Deception

- Theory of Mind concepts/understanding are hard to acquire
- But there are cognitive capacity benefits once acquired, explains discontinuity between humans and animals
- ➔ Animals fail to gain these enhancements, no virtuous circle for them, as per language
  
- Even if animals don't have beliefs, desires, etc., very useful to assume these when predicting and manipulating them
- Theory of Mind concepts have wide-ranging applicability as tools for cognitive modelling shortcuts
- ➔ Explains human (over)generalisation of ToM concepts, defensible to apply to animals, but not computers?

# 10.3 Evaluation: Theory of Mind & Deception

- What might Theory of Mind possession also imply?
  - Humphrey (1983)
    - Consciousness evolved for predicting the behaviour of others
      - Know our own beliefs/desires
      - Predict our future behaviour in a given situation
      - Assume other humans have beliefs and desires similar to our own
      - Predict behaviour of others by predicting ourselves
- ➔ Theory of Mind = an indicator of consciousness?
- ➔ Consciousness = an element of ToM reasoning?
- ➔ Necessary but not sufficient; high general cognitive capacity also needed to develop Theory of Mind skills?

# 10.4 The Real Origins of General Intelligence?

- Humphrey (1988): Primates have complex social lives, high intelligence necessary for social problem solving
- Byrne & Whiten (1988): human intelligence evolved as a result of social pressures
- ➔ High social intelligence incidentally useful for other problem solving too?
- Reznikova (2007): social living complex, but solitary living demanding, and risky
- Gottfredson (2007): human social skills are never related to general intelligence
- ➔ Why the discrepancy?

# 10.4 The Real Origins of General Intelligence?

- Gottfredson (2007)
  - Human innovations (tools etc.) have profound implications for survival
    - Each innovation raises quality of life and life expectancy for the group on average
    - But deadly innovations raise relative risk at the lower intelligence end of the group
    - Cognitive capacity to identify dangers and avoid concentration lapses is essential
- ➔ Deadly innovations put low cognitive capacity genes at more risk than high capacity genes within a group

# 10.4 The Real Origins of General Intelligence?

- Gottfredson (2007) *cont.*
  - Ache tribe of Paraguay (hunter gatherers)
    - Hunting = dangerous 'technology' (weapons, poisons, unobserved snakes)
      - ▶ Disproportionately removes young males from gene pool
      - ▶ Orphaned children often killed, magnifying genetic effects
    - ➔ Evolutionary effects of technology, with its associated fatal accidents, are intense
  - ➔ Once technological innovations reach a certain point/quantity general intelligence ratchets up

# 10.5 Animal, Human, and Machine Intelligence

- Animal intelligence
  - All animals must prioritise and reconfigure goals
  - Predictors of success/failure must be learnt effectively
  - ➔ Requires a general control mechanism alongside domain-general cognitive capacity
- Performance and learning ability in particular domains is influenced by
  - Genetically programmed modules
  - Focused cognitive capacity, sensory acuity
- ➔ These may result in better or worse learning in a domain than might be expected from basic cognitive capacity

# 10.5 Animal, Human, and Machine Intelligence

- Why are humans so different?
  - ***High general cognitive capacity***
    - Fuelled by dangerous innovations
    - Enabling enhanced learning ability, sequencing, and goal management
  - ***Focused cognitive capacity***
    - Leading to direction of interest towards properties of objects, meanings of symbols, and people's mental states
    - Together giving the resources to acquire versatile tool use, expressive language, and Theory of Mind concepts
  - ***Cognitive fringe benefits***
    - High cognitive capacity is enhanced still further by the mental tools that it is able to acquire

# 10.5 Animal, Human, and Machine Intelligence

- Why are computers so different?
  - Failure to achieve human intelligence
    - Lack of meaning and understanding
    - Lack of everyday common-sense
  - Failure to achieve animal intelligence
    - Inefficient learning and memory
    - Ineffective inductive reasoning
  - Barriers to AI difficult to surmount, but related, and point one single fundamental architectural problem?
- ➔ Is the missing something common to animal and human brains, or unique to human cognition?

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