PS452 Intelligent Behaviour

Part 3: Intelligent Behaviour in Animals

4) Theory of Mind & Deception

➲ *The most complex behaviour of all?*

- Modular Machiavellianism?
- Compromised Cognitive Capacity?

Lecture 10:
Theory of Mind & Deception?

1) **Theory of Mind: A Tool for Deception**
- Evidence for ToM in animals

2) **The Special Case of Deception?**
- Deception in the wild
- Deception in the laboratory
- Return of the crows

3) **Summary: ToM & Deception**

   Similar patterns to other domains

4) **Does Human General Intelligence Really Have Social Origins?**

   Darwin awards and evolution

5) **Intelligent Behaviour, Ten Lectures On**

   Animals versus humans versus computers

1) Theory of Mind: A Tool for Deception

- *Theory of Mind:*
  A popular concept in child psychology

➲ Belief that others have *mental states:*
beliefs, desires, knowledge, goals, etc.

➲ Belief that others are *intentional systems*

- False belief, e.g. *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: the box ✘
Older children: the basket ✔

➲ Task difficulties ➔ do not understand beliefs and knowledge in others

- Humans: deception often intended to influence the *beliefs* of others, *intentional*

➔ Easier to deceive if *know* that it is necessary to change the beliefs of others

➔ Must guess the beliefs and must know what the beliefs should be changed to

➲ ToM = deceivers' toolkit

➲ ToM understanding defects make it *hard to deceive others?*

***Domain general* vs. *domain specific*?**

- Humans are social animals

➲ Advantages to individual if:

Can persuade other people to co-operate
Can obtain benefits by deceiving/cheating
Can spot deceit/cheating by others

- Cosmides:

➔ Complex thinking only initiated if tasks are phrased in a cheater detection context

➔ These skills are vital for survival, dangerous to leave learning to chance

➲ Processes underlying skills must be *modular;* genetically programmed

- Baron-Cohen:

➔ Autists: unique problems in this domain

➲ Must have a *defective module*

- Roberts (2007):

➔ *Contextual facilitation methodology* is suspect

➔ Logic effects within domains unexplained

➲ Unlikely to be a *cheater detection* module

- Happaney & Zelazo (2007):

➔ False-belief tasks are more demanding than the baseline inference tasks

➔ Autism effects suggest that ToM thinking is just *difficult* rather than modular

➲ Demanding of cognitive capacity

- Humans have ToM because of high cognitive capacity plus attentional focus

➔ Develop ToM expertise, a *virtual module* at best (Moses & Sabbagh, 2007)

➲ Gives cognitive capacity benefits (cf. language)

Theory of Mind in Animals?

Pearce (2008)
Reznikova (2007)

- Byrne & Whiten (1988): group members are tools, use them to achieve goals

➲ Intelligence needed to control such complex 'devices'?

- Many animals have complex social hierarchy/interactions (Reznikova, 2007):

  Cooperation
  Communication
  Recognition
  Kinship
  Vendettas
  Alliances
  Intelligent recruitment

➲ High cognitive demands?

➲ Any genetic tendency to form a proto-*social module* = a huge head start?

- *Domain-general* versus *domain-specific* debate has implications for animals

❶ *Domain-specific:* modular ToM is just as vital for any social animals as for humans

➲ Likelihood of forming a specialised ToM module is related to the complexity of animal social lives

➲ Specialised module not *general intelligence* by definition, even if processes are clever

➲ ToM thinking related to complexity of animal social lives, *not* cognitive capacity

❷ *Domain-general:*
ToM thinking is just difficult

➲ ToM thinking in animals is predicted by cognitive capacity

➲ ToM thinking = another intelligence test

- Whiten & Byrne (1988) [see Byrne, 1995]

➔ To what extent are primates [etc.] *natural psychologists* or *mind readers*

➲ Can guess/manipulate beliefs of others?

- Seyfarth & Cheney (2003):

➔ No trace of intentionality/ToM in vervet monkey alarm calls

➲ Only chimpanzees *might* display any ToM

- Chimpanzees (& dogs etc.) skilled at making inferences about gaze direction

❶ *Follow gaze to find something interesting*

versus

❷ *Follow gaze to see what X is thinking*

➲ ❶ similar to chimpanzee symbol use (L9)

❶ *This symbol can obtain an apple*

versus

❷ *This symbol stands for apple*

ToM Experiments in Animals

- See Vonck & Povinelli (2006)

❶ Learning task, phase 1

① First trainer hid food under one of several cups behind a screen

② Second trainer arrived

③ Trainers pointed to one cup each

➔ Chimpanzees *eventually* learnt to select cup pointed to by knowledgeable trainer

❷ Learning task, phase 2: *can chimpanzees understand concept of trainer knowledge?*

④ Food hidden under cup by third trainer

⑤ First trainer observed, second trainer wore a bucket (chimpanzees familiar)

⑥ First & second trainers pointed to cups

➔ Two chimpanzees immediately correct, one correct after training, one failed

❸ Postscript task

- Chimpanzees learnt to use natural begging gesture to obtain food

➔ Used this even on non-seeing trainers (e.g. wearing bucket)

➔ Eventually learnt, used a face visibility cue

- Slow improvement (phase 1)

➲ Learning task rather than natural ToM

- Individual differences

➲ Difficult task, limits of cognitive capacity

- Learning set task ***NOT*** ToM task?

➲ Phase 1: chimpanzees learnt that certain types of trainer more useful than others?

➲ Phase 2: learning set generalised

- Chimpanzees too young (5/6 yrs)?

➔ Older chimpanzees better (but possible for elephants too, see Pearce, 2008)

➲ Older chimpanzees know more about usefulness of human eye visibility?

- Chimpanzees only use ToM with other chimpanzees (Tomasello et al., 2003)?

① *D*ominant and *S*ubordinate chimpanzees observed food hiding, both released

➔ *S* chimpanzee did not take food

② *S*ubordinate chimpanzee *only* could observe food hiding, both released

➔ *S* chimpanzee *did* take food

➲ *S* chimpanzee understood knowledge of *D*?

- Speed of learning fast but irrelevant

➲ Already had appropriate past experience

- Povinelli & Vonck (2003): simple rule;

➲ *Don't go after the food if the dominant was visible when the food was placed in the arena [because dominant has seen it and knows where it is]*

- Slow learning for novel tasks = important

➲ ToM knowledge should permit faster decisions, whole point of ToM module

- No special ToM capability or potential in chimpanzees

➲ Chimpanzees at least 'know' that group members might be *useful* or *dangerous*

➲ But not their *mental states*

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."*

- In groups of co-operating individuals, some skills may be particularly beneficial

➔ More offspring (genes) are passed on for:

❶ Members who deceive to obtain benefits, who are tactical and avoid getting caught

❷ Members who spot deceivers, recognise them, and punish them in future

➲ *Evolutionary arms race*

➲ *Eventually a sophisticated understanding of mental states and motives*

➲ *Maintains group integrity via uneasy stand-off between cheaters and spotters*

- Deception-related skills can enhance success of individuals within groups?
- Deception-related skills develop before sophisticated ToM concepts?

➔ Deception skills more developed than general ToM skills in social animals?

❶ Attentional bias towards deception-related behaviour, rapid learning

❷ Development of deception/ counter-deception module

➲ Proto-ToM module?

- Interesting deception has *intent:*

➔ Deliberate wrong signals to animal's advantage

Change behaviour: 1st Order
Change beliefs: 2nd Order

➲ Must not be one specific behaviour pattern accountable by evolution, trial and error, or association

Deception in the Wild (trivial)

- Camouflage and physical mimicry not interesting (morphological deception)
- Out of control of the animal

➔ But coloured moths tend to land on appropriate surfaces (Partridge, 1978)

➲ Evolution is a powerful mechanism for creating complicated behaviour

Deception in the Wild (interesting)

- Correct behaviour intentionally applied in wrong context to gain an advantage
- Primates are popular study targets
- Simpler animals are neglected, but often just as capable

➲ Overview of different species needed to give idea of relationship between cognitive capacity, intent, and deception

Mimicry: Fireflies

- Many species of fireflies: different light patterns are unique to different species
- Males have a distinctive mating pattern, females have a distinctive response
- *Photenus* preyed upon by *Photuris* firefly

➔ Female *Photuris* mimics the response of female *Photenus* to lure males

➔ Mimicry not perfect, *Photenus* males sometimes veer away after approach

➲ Evolutionary arms race

➲ Unlikely to be intentional!

Food-Calling (Chickens)

- Cockerels discover food ➔ courtship call

➔ Never call if *only* other males present

➔ Sometimes call if no others present and food is edible

- Marler et al. (1986):

➔ Edible food: will call to any visible female

➔ Inedible food: may call (less strongly) to unfamiliar females

➲ Marler *et al.*: deception, evidence of intention and communication in chickens

➲ Behaviour better explained by an additive arousal model (10 = threshold)?

	Edible food (+10)	Inedible food (+0)
Only male (–5)	✘ (5)	✘ (-5)
No one (+0)	✔ (10)	✘ (0)
Familiar female (+5)	✔ (15)	✘ (5)
Unfamiliar female (+10)	✔ (20)	✔ (10)

Alarm Calls (Birds)

- Much scope for alarm call misuse
- Munn (1986): tropical birds feeding on insects under forest canopy
- Mixed species flocks: some serve as sentinels (e.g. warn of hawks)
- Feed on insects flushed out by others

➔ Sentinels known to give false alarm calls

➔ Other birds scatter, sentinels collect food

➔ Particularly likely when feeding young or when several birds chasing same insect

➲ A desire to alter beliefs (2nd order)?

➲ A desire to alter behaviour (1st order)?

➲ Or effective learnt procedure (0 Order)?

Injury Feigning (see Ristau, 1991)

- Sandpiper incubates eggs, is disturbed by a ground-based predator:

➔ Will sometimes leave nest, feigning injury, leading away predator by dragging a wing

➔ When the predator is at a safe distance, the bird flies back to the nest

➔ Sensitive to gaze direction of predator (more likely if gazing at the nest)

➔ Always leads away from the nest

➲ What underlies this?

Overall: Non-Primates

- Most behaviour limited to one particular act (c.f. tool use)
- Deceptive behaviour possible without clear requirement for intentionality

➲ Caution when interpreting primates

Primate Deception

- Hyman (1989): researchers' contradiction?

➲ Central to chimpanzee social life but …

➲ actual instances of deception are rare!

- Byrne & Whiten (1987, 1988, 1991); Whiten & Byrne (1988):
- Problem: interesting deception rare

❶ Expert deceiving species also expert deception spotters

❷ Animals can recognise each other

➲ No more deception than other animals

- Rare behaviour = accident, not deliberate
  Frequent behaviour = learning

➲ Lack of ToM thinking in other research implicates caution?

Tactical Deception in Primates

- Whiten & Byrne (1988), Byrne (1995)
- Tactical deception: flexible, effective
  acts vary according to context
- Questionnaires to collect primate deception
  anecdotes from many researchers

➔ Five categories of deception identified

➔ Chimpanzees researchers most
likely to reject learning/behaviourism

➲ Chimpanzees impress skeptics?

➲ Chimpanzees attract certain researchers?

❶ ***Concealment:*** *agent conceals from target*

E.g. not making a sound signal,
not gazing at a desirable object

➔ Baboons may turn backs on others when holding food

➲ *Knowledge of what others can see?*

➲ *Learned response from previous occasions?*

❷ ***Distraction:*** *agent diverts target's attention away from object etc.*

Looking away, vocalisation, leading away

➔ Baboon pursued by others, stood on hind legs scanning distance

Others broke off chase, seeking predators

None detected by humans

➲ *Knew that alarm would stop chase?*

➲ *Wrong behaviour activated by anxiety?*

❸ ***Creating an image:*** *target caused to misinterpret status of agent*

➔ Chimpanzee hurt during fight

For a week, walked with a limp *only* when in view of opponent

➲ *Tried to induce feelings of guilt?*

➲ *Or associated opponent with pain?*

❹ ***Manipulation of target (*T*) using social tool (*ST*):*** *Agent uses stooge to affect target*

➔ Adult baboon digging up food (**T**)

Juvenile watching suddenly screamed (**A**)

Second adult (**ST**) chased first adult (**T**)

Juvenile (**A**) remained to eat food

Repeated this behaviour several times

➲ *Cunning manipulation of beliefs*

➲ *Accident followed by learned association?*

❺ ***Target* (T) *deflected to fall guy* (FG):**
Agent diverts target's attention to stooge

➔ Adult male macaque eating (**A**) was approached by dominant male (**T**)

First male (**A**) suddenly attacked and chased nearby female (**FG**)

Dominant male (**T**) continued chase, first male (**A**) recommenced eating

➲ *Knew that dominant male could be duped?*

➲ *Anxiety triggered by threat to food, displaced to non-dominant ape?*

➲ ***Most sophisticated?***

Chimpanzee *C* opened box, found food

Dominant chimpanzee *D* was approaching

C shut box, walked away until *D* departed

C reopened box, took bananas

D hiding behind a tree, took bananas

➲ *Novelty and counterdeception?*

Patterns?

➔ Chimpanzees: widest range of behaviour

➔ More than gorillas

➲ Superior social intellect?

➲ Or gorillas have closer family groups?

➔ ❹ and ❺ not reported for Chimpanzees

➲ Not intelligent enough?

➲ Or too intelligent to fall for these?

➔ Some (e.g. lemurs) have no reported acts

➲ Surprising; even birds show deception

- For all of the above

➲ ***RECORDS ARE INCOMPLETE?***

- Deceptions are taking place by definition

➲ But little convincing evidence for (widespread) intentionality

➲ Lack of theory of mind evidence forces us to accept a lower level interpretations

- Anecdotes of rare behaviour problematic

❶ No base rates for uninteresting accidents

❷ Reporter bias

➲ Tantalising glimpses at best

Deception in the Laboratory

- Woodruff & Premack (1979):

  Chimpanzees taught to deceive selectively?

① Food concealed in one of two boxes in view of, but out of reach from, ape

② Trainer entered room and chose a box

❶ Cooperative trainer gave food to ape if correct, otherwise ape got nothing

❷ Competitive trainer kept food if correct, otherwise ape got food

③ Ape had opportunity to influence trainer

➔ Cooperative person: better than 50% success straight away, all four apes

➲ Apes easily transmit positive information (gaze and pointing), but unintentional?

➔ Competitive person: better than 50% success to begin with (took longer)

➔ Eventually declined to chance

➔ Two apes took long time to achieve this

➲ Suppressing gaze difficult for apes: individual differences in voluntary control

➔ For two apes, performance by competitive trainer became worse than 50% success

➲ Learnt to give misleading cues (pointing to incorrect container, misusing gaze)

④ Experiment reversed: trainer pointed to container, ape made choice

❶ Cooperative trainer pointed correctly

❷ Competitive trainer attempted to mislead

➔ All apes eventually able to read cooperative cues correctly

➔ All but one able to ignore misleading cues, considerable individual differences

[• Dennett (1983): what if clear boxes were introduced for one trial?]

[• Inverted tube trap task results imply that clear box would make no difference?]

- Woodruff & Premack: chimpanzees learnt to mislead and ignore misleading cues

➲ Intentional communication (first order)?

- Problem: trainers knew their statuses

➲ Double-blind experiment impossible

- Slow learning/transfer: learned to solve problem rather than showing ToM skill

➲ Especially with poor ToM evidence earlier

- Apes were young: less than five years old by the time the study ended

➲ Humans need to learn skills of deception

➲ But adult chimpanzees are dangerous

- Mitchell & Anderson (1997): Capuchins can learn this task, similar pattern

➲ ToM even less likely

Return of the Crows

❶ De Kort et al. (2007): Various species of corvid cache food, but may be *raided*

- Individual differences in raiding tendency

- If a *known* raiding bird is in the vicinity

➔ Caching delay, wait until raiding bird is distracted or departs

➔ Caching behind obstacles

➔ Creation of false caches

- Behaviour is modified by the gaze direction of *known* raiding bird

➔ Caching distantly if observed, nearby if not

➔ Re-caching if observed

- In general

➔ More selective choice of caching locations if previously raided

- And raiding birds are very sensitive

➔ If observed, raiders more likely to re-cache than non-raiders

➔ Will raid a cache if neutral bird observing, not raiding if observed by the caching bird

❷ Competitive foraging behaviour

➔ Foraging: ***S*** raven learnt to open food boxes in low reward zone to draw away ***D*** raven

➔ ***D*** raven learnt to stop pursuing, foraged for itself instead

➲ No less sophisticated than primates

3) Summary: ToM and Deception

- Chimpanzee: little evidence of ToM

➔ Tantalising glimpses, nothing more

➲ Would expect better evidence if complex society ➔ *proto* ToM module

➲ Deception findings add little to this

➲ **ToM and Deception related to cognitive capacity, NOT sociability**

- ToM thinking and deception = elaborate/difficult learning tasks

➲ Performance of chimpanzees/corvids/other animals exactly in line with other findings:

Learning, problem solving, tool use, language, communication etc.

➲ Attentional focus also likely to impact

- No evidence for special ToM/deception performance even in social animals

➲ Human ToM is not ‘modular’, consequence of high cognitive capacity/attentional bias

➲ Develop ToM expertise, a *virtual* module

- Easier to reason about what we can name

➔ Can express/discuss belief desire concepts

➲ Versatile language also necessary for ToM

- ToM hard to acquire

➔ But cognitive capacity benefits once acquired, explains discontinuity

➲ Animals fail to gain, no *virtuous circle*

- Even if animals don’t have beliefs, useful to assume these when manipulating them

➲ ToM universal applicability as cognitive shortcut ➔ human overgeneralisation

What Might ToM Also Imply?

- Humphrey (1983): consciousness evolved for predicting the behaviour of others

- Know our own beliefs/desires

➲ Predict our future behaviour

- Assume that other humans have beliefs desires similar to our own

➲ Predict behaviour of others by predicting behaviour of ourselves

➲ ToM = an indicator of consciousness?

➲ Consciousness needed for effective ToM?

➲ Necessary but not sufficient; high WMC also needed to develop skills?

4) Does Human Intelligence Really Have Social Origins?

- 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?

- Gottfredson: human innovations (tools etc.)

➔ 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

➲ Low cognitive capacity genes at more risk than high cognitive capacity genes within the group

- 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 pressures of effects of fatal accidents are intense

➲ Once technological innovations reach a certain point, intelligence ratchets up

5) Intelligent Behaviour, Ten Lectures On

Animal Intelligence

- Predictors of success and failure must be learnt effectively and rapidly
- All animals must prioritise and reconfigure goals as necessary

➲ Requires central control mechanism and sufficient cognitive capacity

- Basic mechanism similar for all animals:

➔ Qualitative species differences for particular tasks indicate

❶ Domain specific modules over-riding domain-general processes

❷ Sensory and attentional differences enhancing or hindering central processes

❸ Huge differences in cognitive capacity

➲ Individual differences within species limits of basic capacity

Why are Humans so Different?

❶ High cognitive capacity

Whose rapid evolution began once innovations reached a danger threshold

- Which in tandem permitted

❷ Sufficient cognitive capacity to develop concept of symbol, versatile language, ToM

- All enhanced by

❸ Attentional bias towards properties of objects, meanings of symbols, and other people's mental states

- Which gave humans

❹ Tools and shortcuts which enabled them to enhance their cognitive capacity still further

Why are Computers so Different?

❶ Lack effective control mechanisms

❷ Ineffective inductive learning

❸ Inefficient memory

❹ Lack of symbol grounding

• Architecture problems?

➲ Biological brains are *not sufficient* for certain aspects of human intelligence

➲ Are they necessary? We do not know

➲ We know virtually nothing about the fundamentals of human cognition

Major Sources

Pearce, J.M. (2008). *Animal cognition & learning (3rd ed).* Hove: Psychology Press.

Reznikova, Z. (2007). *Animal Intelligence*. Cambridge: CUP.

References

Byrne, R. (1995). *The Thinking Ape*. Oxford: OUP.

Byrne, R., & Whiten, A. (1987). The thinking primate's guide to deception. *New Scientist, 3rd December,* 54-57.

Byrne, R., & Whiten, A. (eds.) (1988). *Machiavellian Intelligence: Social Expertise and the Evolution of the Intellect*. Oxford: OUP.

Byrne, R., & Whiten, A. (1991). Computation and mindreading in primate tactical deception. In A. Whiten (ed.). *Natural Theories of Mind*. Oxford: Blackwell.

De Kort, S.R., Tebbich, S., Dally, J.M., & Clayton, N.S. (2007). The comparative cognition of caching. In E.A. Wasserman & T.R. Zentall (eds.) *Comparative cognition: Experimental explorations of animal intelligence*. Oxford: OUP.

Dennett, D.C. (1983). Intentional systems in cognitive ethology. *Behavioral and Brain Sciences, 6,* 343-355.

Gottfredson, L.S. (2007). Innovation, fatal accidents, and the evolution of general intelligence. In M. J. Roberts (Ed.), *Integrating the mind*. Hove: Psychology Press.

Humphrey, N.K. (1983). *Consciousness Regained.* Oxford: OUP.

Happaney, K.R., & Zelazo, P.D. (2007).Less specificity in higher cognitive mechanisms. In M. J. Roberts (Ed.), *Integrating the mind*. Hove: Psychology Press.

Humphrey, N.K. (1988). The social function of intellect. In R.W. Byrne, & A. Whiten (eds.). *Machiavellian Intelligence: Social Expertise and the Evolution of the Intellect*. Oxford: OUP.

Hyman, R. (1989). The psychology of deception. *Annual Review of Psychology, 40,* 133-154.

Marler, P., Dufty, A., & Pickert, R. (1986). Vocal communication in the domestic chicken: II. Is a sender sensitive to the presence and nature of a receiver? *Animal Behaviour, 34,* 194-198.

Mitchell, R.W, & Anderson, J.R. (1997). Pointing, withholding information, and deception in capuchin monkeys. *journal of Comparative Psychology*, *111*, 351-361.

Moses, L.J., & Sabbagh, M.A. (2007). Interaction between domain general and domain specific processes in the development of children's theories of mind. In M.J. Roberts (Ed.). *Integrating the mind*. Hove: Psychology Press.

Munn, C.A. (1986). Birds that 'cry wolf'. *Nature, 319,* 143-144.

Partridge, L. (1978). Habitat selection. In J.R. Krebs, & N.B. Davies (eds.). *Behavioural ecology: an evolutionary approach*. Oxford: Blackwell.

Pearce, J.M. (2008). *Animal cognition & learning (3rd ed).* Hove: Psychology Press.

Povinelli, D.J., & Vonck, J. (2003). Chimpanzee minds: Suspiciously human. *Trends in Cognitive Sciences*, *7*, 157-160.

Ristau, C.A. (1991). Before mindreading: attention, purposes and deception in birds? In R.W. Byrne, & A. Whiten (eds.). *Machiavellian Intelligence: Social Expertise and the Evolution of the Intellect*. Oxford: OUP.

Roberts, M.J. (2007). Contextual facilitation methodology as a means of investigating domain specific cognition. In M.J. Roberts (Ed.). *Integrating the mind*. Hove: Psychology Press.

Seyfarth, R.M., & Cheney, D.L. (2003). Signallers and receivers in animal communication. *Annual Review of Psychology*, *54*, 145-173.

Tomasello, M., Call, J., & Hare, B. (2003). Chimpanzees understand psychological states – the question is which ones and to what extent? *Trends in Cognitive Sciences*, *7*, 153-156.

Whiten, A., & Byrne, R.W. (1988). Tactical deception in primates. *Behavioral and Brain Sciences, 11,* 233-244.

Vonck, J., & Povinelli, D.J. (2007). Similarity and difference in the conceptual systems of primates: The unobservability hypothesis. In E.A. Wasserman & T.R. Zentall (eds.) *Comparative cognition: Experimental explorations of animal intelligence*. Oxford: OUP.

Woodruff, G., & Premack, D. (1979). Intentional communication in the chimpanzee: the development of deception. *Cognition, 7,* 333-362.