PS452 Intelligent Behaviour

Part 3: Intelligent Behaviour in Animals

3) Animal Communication

➲ *Complex acts or mindless signals??*

- Complex communication in the wild?
- Linguistic virtuosity in the laboratory?

Lecture 9:
Animal Communication

1) **What is Communication?**

- The language debate
- Communication and intelligence

2) **Natural Animal Communication**

- Bees (and Ants)
- Vervet monkey alarm calls

3) **Taught Animal Language**

- The sign language projects
- The artificial language projects
- Evaluation: language teaching

4) **What Does Communication Reveal About Intelligence?**

Same as L7 and L8!

1) What is Communication?

- Something that alters the behaviour of others?

➲ Appearance, (markings, gesture, posture), sounds, smell, touch, taste all implicated

- Often more specialist in humans

➲ *Language* is used to communicate

- **Uninteresting question**:
  Do (can) animals have (learn) language?

  Instead:
  What does (can) communication tell us about animal intelligence?

➲ Necessary to avoid a theoretical abyss

The Language Debate

- Human language has at least the following (e.g., Aitchison, 1989; Pearce, 2008):

  Arbitrary symbols

  Semanticity / reference (meaning)

  Displacement (in time, space)

  Productivity (discrete units in combination)

➲ Endless debate (futile):
Do (can) animals have (learn) language

- Various vested interests:

  Nativists
  (language = genetic predisposition?)

  Behaviourists
  (language = lucky accident?)

  Philosophy
  (language = marker of thought?)

  Animal rights?

➲ Beware!

Language and Intelligence

- Humans are adept linguists
- Even if language has a genetic precursor, its use still requires cognitive capacity

➔ Most humans can learn to use language whatever their intelligence

➔ But low intelligence almost certainly associated with less effective use

➲ Language very demanding of WMC

- Language is a powerful cognitive tool

➔ Meo, Roberts & Marucci (2007): Verbalisable matrix items easier

➲ Language can enhance WMC

➲ Animals triply penalised? Complex communication systems:

Harder to learn (irrespective of genetics)
Harder to use
Capacity enhancement harder to achieve

- Certain types of animal communication deserve close attention

❶ *Complexity*

Learning/use ➔ high cognitive capacity?

High-level concepts and understanding?

Fringe benefits

❷ *Intentionality*

Emitted signals or deliberate acts

Intentionality level (cf. Dennett)

➲ What has developed naturally?

➲ What can be achieved with assistance?

2) Natural Animal Communication?

Aitchison (1989)
Pearce (2008)
Reznikova (2007)
Seyfarth & Cheney (2003)

- The most interesting examples only for the most social of animals

➔ Cooperation and conflict between members of social groups

➲ No point talking to oneself!

- Sophisticated communication requires sophisticated learning/cognition?

➔ Symbols, understanding, and intent versus learned associations (or worse)?

➲ Test intelligence by ***testing*** communication?

- Animals infer a great deal from gesture (e.g. gaze direction, body movements)

➲ Not symbolic and output may not be under the control of the animal anyway

- Some animals control their gestures in order to deceive?

➲ Non-symbolic communication is only intelligent if intentional deception (L10)

- Some communication can be interpreted as comprising arbitrary signals

  “My territory: go away”

  “Excellent food here”

  “Flying predator approaching”

➲ Computers use symbols, don’t get too excited!

Animals and Computers as Symbolic Communicators

- Some animal communication appears impressive

➲ Must be put into context

- Natural language understanding is the hardest task for AI
- Computers excel at executing unintelligent procedures

➔ Computers can communicate within restricted domains (e.g. SHRDLU)

➲ Look for (lack of) underlying understanding in computers and animals

➲ *Do the animals understand what they mean? Computers do not*

Bees (and Ants)

[Pearce, 2008; Reznikova, 2007]

- Foraging recruitment

① Bee finds nectar source

② Bee returns to the hive and performs a series of movements

③ If generates enough activity, recruits bees to fly to correct location

➲ Excellent spatial abilities: can signal a direct route even when not directly taken

- Nearby food: *round dance*
- Distant food (over 100m): *wagging dance:* Figure 8-shaped:

➔ Distance = length of middle section

➔ Direction = orientation of dance in relation to the sun/hive

➔ Food quality = provided by samples

➔ Wing sounds enhance salience

➲ *Symbolic* and *displaced*

- However, restricted in understanding and communication

❶ E1 [von Frisch] food source placed several yards in the air

➔ Bees released at food source returned to hive and performed dance

➔ Other bees searched for several hours, but could not find food

➲ Bees cannot communicate height

❷ E2 [Dyer] food source was moored in the centre of a river

➔ Bees failed to recruit others to collect it

➲ Bees rejected possibility of food in river?

❸ E3 [Riley et al.] Recruited bees leaving hive were captured and displaced

➔ Bees did not modify journey

➲ Poor evidence for cognitive map

- Bees cannot communicate some concepts
- *Bees do not know that they cannot communicate these concepts*

➔ Performance is ***brittle***

➔ Simple genetic links to dance components

➲ Bees occupy a micro-world (c.f. SHRDLU); high performance in the right situation but errors imply limited understanding?

Ants [Reznikova, 2007]

- Even more sophisticated than bees? Can communicate via antenna

➔ Routes to obtain food, complex routes = longer 'messages'

➔ Can develop communication short-cuts to denote key landmarks

➲ Puts many mammals to shame

➲ Computers can do this too!

Vervet Monkeys

[e.g. Seyfarth & Cheney, 2003]

- Wide variety of sounds.
- Some of these are *alarm calls*
  chutter: puff adder/cobra
  rraup: eagle
  chirp: lion/leopard
  uh: hyena/human
- Seyfarth, Cheney & Marler (1980):

➔ When a call is made, others repeat calls and respond appropriately:
snake; stand on hind-legs, look around;
eagle; dive into undergrowth;
lion; climb a tree

➔ Respond in the same way to taped calls

➔ Changing volume and duration of calls has no effect on strength of response

➔ Second call, or appearance of predator *does not* lead to others repeating the call

Not adding new information

➲ Calls have meaning?

Do the calls have intentionality?

- Cheney & Seyfarth (1985, 1991):
  Varied company and its (visible) status

➔ More likely to call when own offspring present than other young ➔ **NOT** 0 order

➔ *NOT r*elated to ***known*** (gaze direction) status of targets ➔ **NOT** 2nd order

- Seyfarth & Cheney (1993, See Pearce):

  Other apes threaten infants,
  only *infants* make baboon alarm call

- Threatening ape hidden in enclosure in view of mother

➔ Young vervet monkey entered, mother *failed* to give any warning

➲ Vervet communication no more than first order (L8)?

➲ Unlikely to be an intentional response at all (see Burghardt, 1985)

Overall

- Difficult to pin down meaning of sounds
- Cheney & Seyfarth (1992):

  Precise definitions are only possible for humans because we have many words

➲ Possible that sounds have *meaning*

➲ Evidence for *intention* is poor

- Many other animals have *contextual* calls

➔ Diana monkeys (different threats)
Macaques (different types of food)
Chickens (aerial versus ground predators)
Prairie dogs (different predators)
Meercats (different predators)

- Many animals show *audience effects*

➔ Chickens
Ground squirrels
Jungle fowl

- Seyfarth & Cheney (2003):

➲ Communication limited because animals cannot attribute mental states to others

Do not know about beliefs,
so cannot change beliefs [L10]

➲ Even chimpanzees find this difficult

➲ Pearce (2008):

No animals interact with sufficient complexity to imply any sort of language

[Not even dolphins, no room for this topic!]

- Language has biologicaland developmental 'baggage'

➲ No need for complexity for most animals, versatile signals suffice

➲ Natural communication reveals no hidden capacity for intelligence/understanding/ intent not already revealed in L7/L8

3) Artificial Animal Language

Aitchison (1989)
Pearce (2008)
Pinker (1994)
Reznikova (2007)
Wallman (1992)

- Natural communication difficult to study; lack of control and unclear meanings

➲ Can primates be *taught* human-like language with understanding/grammar?

- Behaviourism roots: any animal can learn some language if correct reinforcement

  Humans lucky enough to stumble upon language by accident?

➲ Initial projects (failed) tried to bring up chimpanzees in human surroundings

- Very vitriolic debate

➲ CAUTION: Researchers may be biased!

The Sign Language Projects

- Apes very dexterous and cannot vocalise in a human way, biological impossibility

➲ Teach them sign language?

Washoe (Gardner & Gardner, 1969)

- Surrounded by humans signing
- Signs acquired by observation/imitation?

➔ No, shaping also not effective, moulding was the most used method

➔ Learnt over 30 signs in 21 months

➔ 130 after four years when project ended

➔ Evidence of understanding: able to give correct (noun) sign when shown slides

➔ *Generalised*

MORE initially used when being tickled, generalised to other games and food

➔ *Overgeneralised*

FLOWER = anything with strong smell

➔ *Creative*: two/three word combinations,

GIMME TICKLE
GO SWEET (take to raspberry bushes)
OPEN FOOD DRINK (open refrigerator)

➔ *No word order*

GO SWEET = SWEET GO
[No rigorous attempt to train]

➔ Claim: word order became more regular

Reached level of a human 2 year old?

➔ After completion, creative signs continued

WATER BIRD

➔ Evidence of teaching signs to others

➲ Clearest evidence for human-like language development and production?

Other Primate Signers

❶ **Koko** the gorilla (Patterson)
Many claims, little evidence

➔ Over 600 signs?

➔ IQ of 85–95 (higher than many humans)

➔ Metaphors, puns, insults, lies, creativity

Joke: saw a frog, signed *RED FROG*
just an error?

Creativity: *EYE HAT;* mask, *WHITE TIGER;* zebra, *COOKIE ROCK;* stale roll

➔ No claims for grammatical structure

Longest sequence:
PLEASE MILK PLEASE ME
LIKE DRINK APPLE BOTTLE

➲ Lack of rigorous analysis,
hard to evaluate claims

❷ **Chantec** the orangutan (Miles, e.g. 1990)

Similar achievements to the others

➔ 150 signs over six years etc.

❸ **Nim Chimpsky (Terrace, 1979)**

- Similar training and achievements to Washoe, but trainer became sceptical
- More data analysis than other projects

➔ Plenty of multi-sign combinations

MORE first word 78% of use
Transitive verbs before object 83% of use

➔ Some words had position preference, others had none

***EAT** NIM*
*MORE **EAT***
*ME **EAT***
***EAT** DRINK*

➔ Individual word rules learnt not grammar

➔ Proportion of utterances that were imitations **increased** with time

➲ Imitation best route to reinforcement?

➔ Longer sequences mainly repetition

16 word sequence longest:

GIVE ORANGE ME GIVE EAT ORANGE ME EAT ORANGE GIVE ME EAT ORANGE GIVE ME YOU

➲ Emphasis rather than information?

➲ Words = tools to obtain gratification rather than symbols with meaning

➲ Grammar difficult to learn, only applied as necessary to obtain gratification

➲ Learnt to play the game (solve problems) rather than understand language?

Interim Evaluation: Sign Language

- Too many claims = anecdotes

➲ Understanding *versus*
happy accidents & researcher bias?

- Skilled users of sign language complain:

➔ Apes did not adhere to conventions, were not trained and observed by skilled users

➔ Many of the counted signs are natural gestures (e.g. scratch, hug)

➲ Overestimated quantity of learned signs (Seidenburg & Petitto, 1979)

- Many studies badly controlled

➲ Unintended cues by experimenters (Sebeok & Umiker-Sebeok, 1980)

- Why the emphasis on grammar?

➲ A key defining feature of language?

❶ Humans have innate grammar?

➲ Can apes learn grammar or not (futile)

❷ Word order can influence meaning

❸ Complex rules to learn

➲ Highlights limits of non-human learning?

➲ Apes learnt to solve (some) problems, but grammar problem exceeds available cognitive capacity for effective learning?

The Artificial Language Projects

- Apes don't seem to sign very well

➲ ASL does not support grammar learning?

- Meaning/origin of gestures problematic

➲ Artificial language involving
symbol tiles or a keyboard

Sarah (Premack, 1971)

- Taught to manipulate magnetic tokens, varied in colour and shape

  mauve triangle = apple,
  black T shape = the colour yellow

- Shaping used for training
- Not rewarded if word order wrong
- Experiments rigorous; long sessions

➔ One chimp from four able to learn system

➔ Over 100 symbols ‘understood’

colours, shapes, sizes
same, different and *if…then*

➔ Appeared to be able to learn the grammar

➔ *Understanding*

if apple then chocolate
(take apple to be given chocolate)

sarah insert banana pail apple dish

query cup equal spoon

➔ *Displacement*

told *brown is colour of chocolate*
(never taught colour brown before)

pointed to brown patch, no chocolate in view

- How much understanding?

- Wallman (1992):

❶ Sessions too narrow, single formats
e.g. *Sarah give Mary* _____

➲ Most symbols redundant

❷ Painstaking training, step by step
Sarah insert banana pail apple dish

➲ Not needed if genuine understanding

❸ Learnt to respond in certain ways to certain patterns of shapes (*slot filling*)?

➲ Apes are good at learning to learn (L7);

➲ Not the same as understanding symbols

Lana (Rumbaugh)

- Giant computer keyboard
- Coloured shapes stood for words
- Request food and drink, communicate with a trainer
- Attempted to teach grammar by shaping

➔ *Generalised* (use of *more*)

Creative (cucumber: *banana which-is green*)

➔ Learnt grammar poorly

Rote learning, colour coding of keys, trial and error (many retries)

Austin & Sherman (Rumbaugh)

- Same system

➔ Can use keyboard to communicate and request objects from each other

➲ But 'understanding' debunked by Epstein, Lanza & Skinner (1980)

Kanzi (Savage-Rumbaugh, 1990)

- This pygmy chimpanzee (bonobo) is claimed to be the biggest success to date
- Another keyboard user
- Not taught with a conditioning regime

➔ Used spontaneously (single words) after observing mother being taught (2 years)

➔ Still needed training after this

➔ Over 150 symbols

➔ *Understanding:* if pressed a key for object, and given a choice, only took named object

➔ Speech comprehension good; claimed to be identical to 2½ year old human

➔ Can respond to spoken instructions

➔ Some evidence of grammar eventually

➔ Still requested food etc. most of the time

Evaluation: Language Teaching

- Patterson:
  language is no longer the exclusive domain of man
- Pinker:
  the chimps are highly trained animal acts

- Clear pattern

❶ Typically, 150 or so signs learnt
(2½ year old child) but meanings unclear

❷ Word order rules (grammar) hard to learn

❸ Long sequences for repetition/emphasis
rather than additional information

❹ 'Conversations' mainly to obtain rewards

❺ Development matches human, then stops

➲ Implications:

Cognitive capacity
Attentional focus
Fringe Benefits
Intelligence

❶ All apes learn around 150 symbols, but do they understand their meaning?

- Creativity implies knowledge of meaning?

➲ But creativity is rare/anecdotal/accidental

- Easy for humans to give symbols names, but same meanings for apes?

➔ Key that Lana pressed to begin requests is named *please*

➲ Repetitive slot filling tasks more like learning/problem solving than language

➔ Lana could request an object (e.g, banana) but great difficulty when asked its name

➔ Lengthy training required before the concept of name understood

➲ Savage-Rumbaugh et.al. (1983): Apes understand few symbols if any

- Savage-Rumbaugh (1987):
  apes are inappropriately taught

➔ Apple out of reach, must
request *apple* to obtain it

➲ Symbol for an apple could mean:

shape equals apple: **CONCEPT** ☺

shape if chosen results in apple: **TOOL** ☹

☹ *Knowing sign to **obtain** is not the same as knowing that a sign **stands for** an object*

➲ *Understanding the use of a symbol is easy*

➲ *Understanding the underlying meaning of a symbol is cognitively demanding*

➲ *Apes don't understand symbols easily, but are aware of the outcomes of using them*

➲ *Learnt symbols, but not **about** symbols*

➲ *Without the concept of meaning, fringe benefits of language are harder to obtain*

❷ Apes cannot easily induce the rules of grammar even when regular. Why?

- Trainers are so keen to reward the use of any signs that word order is forgotten?

☺ *If apes can obtain rewards without using grammar then why bother?*

- Sequencing is a difficult task

☹ *Rules of grammar are very cognitively demanding to learn, apes have difficulty?*

❸ Long symbol sequences are rare and uninformative. Why?

- Majority of 'conversations' are about food and gratification

☺ *Perhaps most ape desires are expressible in two or three words at the most*?

- Complex thinking for complex sentences
- Sequencing is a difficult task

☹ *Multiple ideas in a single sentence overwhelm memory capacity?*

❹ Apes virtually only use language to obtain gratification Why?

- Symbols rarely used for information, for the sake of it, or to discuss objects

➔ Kanzi is only real exception

- Apes are taught language using rewards

☺ *Language becomes a tool for getting rewards*

- Chimpanzee attentional focus suits tool use, but not deeper level understanding

  Chimpanzee: *what can I **do** with this*
  Human: *what **is** this*

☹ *No attentional focus for linguistically relevant concepts*

➲ *Similarly sized brains different. NOT randomly set up connectionist networks*

➲ *Attentional focus detracts from cognitive capacity, learning difficulties amplified*

❺ All apes reach the proficiency of a 2½ year old child and then stop. What is the significance of this?

➔ Humans: a threshold before rapid gains

➔ Apes get stuck, not a threshold for them

- Language learning is a hard task
- Apes unlikely to have specialised short term verbal memory
- Lower cognitive capacity than humans

- Cognitive capacity restricts

  Learning of underlying meanings
  Learning of word order rules
  Understanding of complex sentences
  Understanding of complex concepts
  Formation of complex sentences

- Attentional bias exacerbates cognitive capacity issues
- Point at which language *enhances* cognitive capacity never reached

☹ *Cognitive problems stack up, learning beyond this point is virtually impossible*

- *Language use by chimpanzees exactly as predicted from learning / problem solving*
- *No cognitive enhancement, nor revealing of hidden untapped mental lives*
- *If chimpanzees could and needed to learn language, they would learn language!*

Other Animals

[e.g., Pearce, 2008; Reznikova, 2007]

- Dogs able to learn verbal commands
- Dolphins and sea lions can learn a semaphore-like language

➲ Comprehending language is easier than producing language

- Parrots (Pepperberg, 1990) more adept than chimpanzees in many ways

➲ Attentional focus *towards* word-sounds, *enhances* cognitive capacity

4) What does Communication Reveal About Intelligence?

- In the wild

➔ Animals who (perhaps) communicate symbolically are unable to say very much

➲ Limited meaning, understanding, intentionality

- In the laboratory

➔ Language learning *exactly* in line with general learning / problem solving ability/attentional focus

➲ How much more is human language ability than high cognitive capacity, complex learning, and attentional focus?

- In a social group, limited communication powers can still be used intelligently

➲ Look for animals exploiting their own strengths, not human strengths (L10)

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