PS452
Intelligent Behaviour

Lecture 9:
Animal Communication

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Part 3: Intelligent Behaviour in Animals

- **Lecture 7: Animal Intelligence Tests**
  Measuring animal cognitive capacity
  - Learning and logic between species
  - The ubiquitous *g* factor

- **Lecture 8: Tools, Puzzles, Beliefs, and Intentions**
  Complex interactions with objects
  - Natural tool use
  - Understanding the properties of objects

Part 3: Intelligent Behaviour in Animals

- **Lecture 9: Animal Communication**
  Mindless signals or deliberate acts
  - Natural communication
  - Taught language in the laboratory

Lecture 9: Animal Communication

- **9.1 What is Communication?**
  - The language debate
  - Communication and intelligence

- **9.2 Natural Animal Communication**
  - Bees (and ants)
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  - Limits to natural communication

Lecture 9: Animal Communication

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  - The ape sign language projects
  - The ape artificial language projects
  - Language or problem solving training?
  - Postscript: teaching other animals language
- **9.4 What Does Communication Reveal?**

9.1 What is Communication?

- General definition: communication is …
  - A signal emitted by an animal, containing information, that may influence the behaviour of others
    - Appearance, (markings, gesture, posture), sounds, smell, touch, taste all implicated

➡ Human language = specialist communication method

The Language Debate

- Human language has at least all of the following (e.g., Aitchison, 1989; Pearce, 2008):
  - Arbitrary symbols
  - Semanticity/reference (meaning)
  - Displacement (in time, space)
  - Productivity (discrete units in combination)

➡ How unique is this?

The Language Debate

- ***Do (can) any animals have (learn) language?***
- Impinges on massively entrenched ideologies
  - Nativists (language = genetic predisposition?)
  - Behaviourists (language = lucky accident?)
  - Philosophy (language = marker of thought?)
  - Animal rights (language = marker of affinity?)

➡ Bad question: leads to endless futile debate

Communication and Intelligence

- Language use ***requires*** cognitive capacity
  - Most humans can learn to use language irrespective of cognitive capacity
  - But low intelligence associated with less effective use (Gottfredson, 2007)

➡ Understanding/producing word strings whose meaning depends upon order is demanding of cognitive capacity

Communication and Intelligence

- Language use ***enhances*** cognitive capacity
  - ▸ Meo, Roberts & Marucci (2007): Matrix items with readily verbalisable elements are easier
  - ➡ Language can enhance cognitive capacity by permitting economical representations
  - ➡ Also, language enhances organised structured thinking
  - ➡ ***Language possession has cognitive FRINGE BENEFITS***

Communication and Intelligence

- Animals triply penalised?
  - Complex communication
    - Harder to learn
    - Harder to use
    - Capacity enhancement harder to achieve
      - Less able to learn language because of lower cognitive capacity than humans
      - Less able to attain cognitive ***FRINGE BENEFITS*** of mastering a language

➡ Language widens cognitive capacity gulf between animals and humans

➡ Likewise gulf in associated mental achievements

Communication and Intelligence

- What aspects of animal communication will provide the best markers for intelligent behaviour?
  - ***Intentional communication***
    - Deliberate acts that imply knowledge of others' mental states
  - ***Complex communication***
    - Learning/use that would require high cognitive capacity
    - High-level concepts such as symbol and meaning
    - Evidence for beginnings of fringe benefits
- What has developed naturally?
- What can be achieved with assistance?

9.2 Natural Animal Communication

- No point developing sophisticated communication system just to talk to oneself

➡ Target investigation on social animals

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

9.2 Natural Animal Communication

- Non-symbolic communication
  - Animals infer a great deal from gesture (e.g. gaze direction, body movements)
  - ➡ But output not necessarily intentional
  - Some animals appear able to use gestures to deceive
  - ➡ Non-symbolic deception investigated in Lecture 10

9.2 Natural Animal Communication

- Symbolic communication
  - Some communication can be interpreted as comprising arbitrary signals, e.g., calls and songs

    “My territory: go away”

    “Excellent food here”

    “Flying predator approaching”

➡ But computer use of symbols is insufficient for intelligence

9.2 Natural Animal Communication

- Computer communication
  - Most effective (and convincing) within highly constrained micro worlds
  - But unintelligent procedures, zero understanding
  - What would be necessary for computers to demonstrate intelligence
    - Adaptability of communication to unusual circumstances
    - Evidence of understanding of the meaning of their output

➡ Same criteria necessary for animals to demonstrate that communication reflects underlying intelligence?

Bees (and Ants)

- Foraging recruitment in bees takes place when plentiful food sources located

  (1) Bee finds nectar source

  (2) Bee returns to the hive and initiates special movements

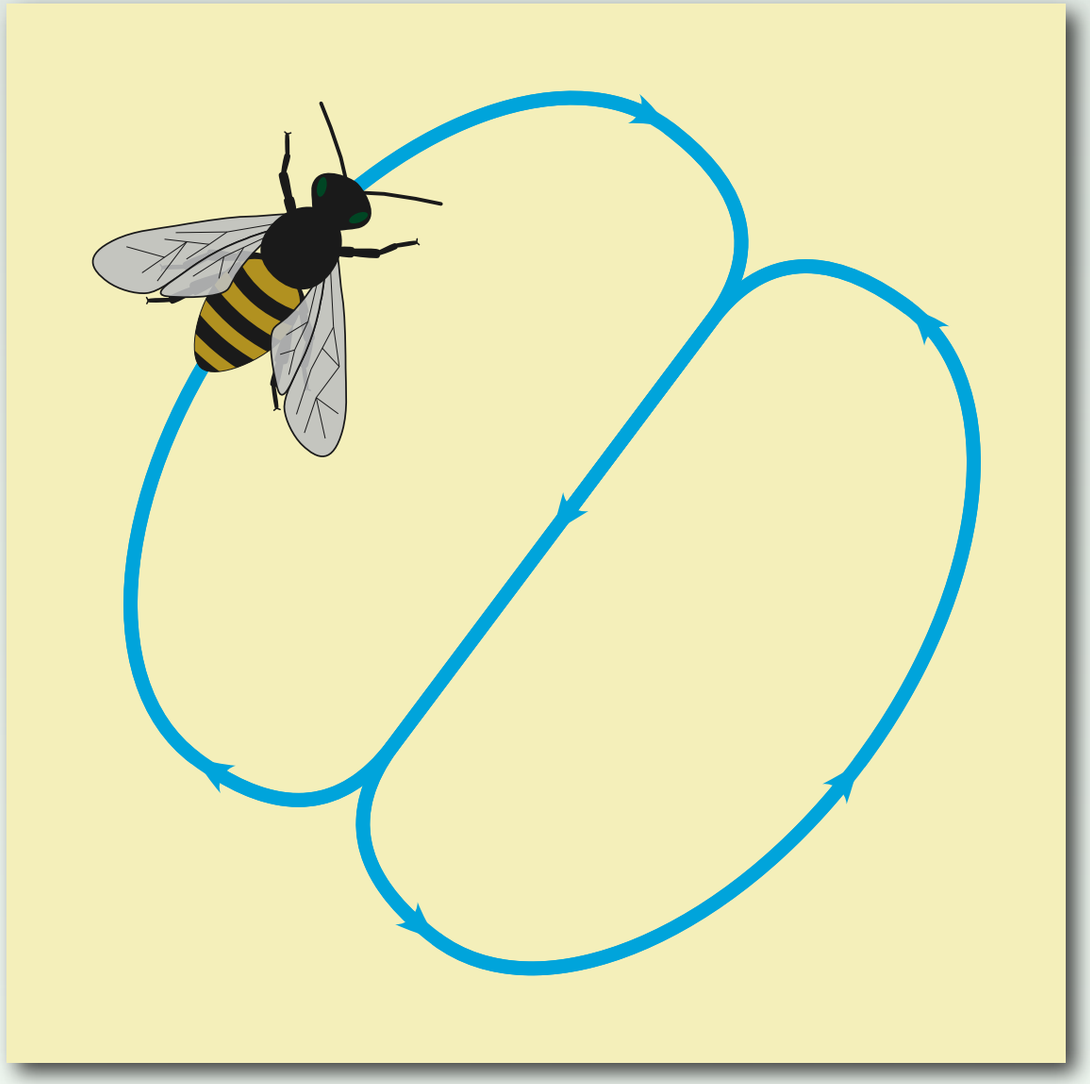
  (3) If sufficient motivation, the recruited bees fly to location

- Excellent spatial abilities: can signal a direct route even when not originally taken

- Nearby food
  - Simple circular dance

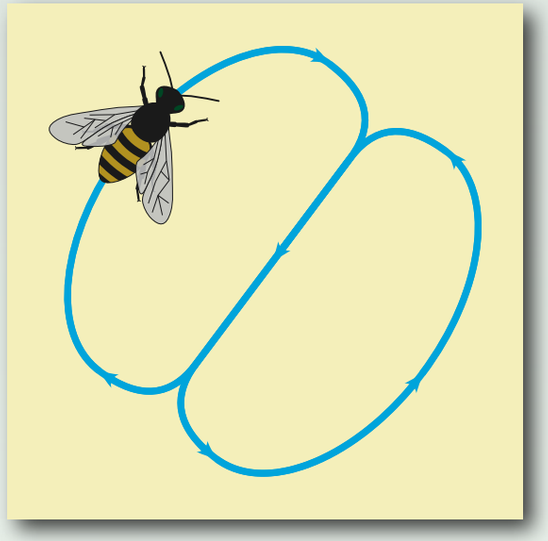
Bees (and Ants)

- Distant food (over 100m)
  - *Wagging dance* (figure 8-shaped)



Bees (and Ants)

- Distant food (over 100m)
  - *Wagging dance* (figure 8-shaped)



    - Distance from food = length of middle section
    - Direction of food = orientation of middle section in relation to the sun/hive
    - Food quality = provided by samples
    - Wing sounds enhance urgency

➡ Communication is displaced ***and*** symbolic

Bees (and Ants)

- No evidence for bee adaptability or understanding

  (1) von Frisch

  - Food source placed several yards in the air
  - Bees released at source returned to hive, performed dance
  - Other bees searched for several hours, could not find food

  ➡ Cannot communicate height, or devise method for this

  ➡ Do not know that they cannot communicate height

Bees (and Ants)

- No evidence for bee adaptability or understanding *cont.*

  (2) 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 = intelligent

  ➡ But signalling bees unable to circumvent this

  (3) Riley

    - Recruited bees leaving hive were captured and displaced
    - ▸ Bees did not modify journey, did not find food

  ➡ Spatial abilities of bees previously over-estimated

Bees (and Ants)

- No evidence for bee adaptability or understanding *cont.*
  - Bees cannot communicate some concepts
  - Bees do not know that they cannot communicate these concepts

➡ Performance is ***brittle***

➡ Bees occupy a natural ***micro-world***

  - Excellent performance a typical situation
  - Errors in unusual situations imply limited understanding?

⏵ Simple genetic links to individual dance elements

➡ Bees are effectively natural computers

Bees (and Ants)

- Reznikova (2007)
  - Ants communicate via antenna
    - ▸ Routes to obtain food, complex routes = longer ‘messages’
    - ▸ Can develop communication short-cuts using key landmarks
    - ➡ Ants communication more sophisticated than bees?
    - ➡ Better communication capability than many mammals
  - Too early to determine level of ant communication adaptability and understanding
  - Could communication be modified to account for unusual circumstances?
  - ➡ In the interim, safest to conclude ant brain processes equivalent to bees

Vervet Monkey Alarm Calls

- Vervet Monkeys emit a wide variety of sounds
  - Some of these are alarm calls

    chutter: puff adder/cobra
    rraup: eagle
    chirp: lion/leopard
    uh: hyena/human

Vervet Monkey Alarm Calls

- Seyfarth, Cheney & Marler (1980)
  - When a call is made, others repeat it and respond appropriately
    - *chutter* (for snake): stand on hind-legs, look around
      rraup (for eagle): dive into undergrowth
      chirp (for lion): climb a tree
  - Taped calls lead to similar behaviour as vocalised ones, no need to see predator or caller
  - Changing volume and duration of taped calls has no effect on strength of response

➡ Calls indicate ***type*** rather than ***intensity*** of danger

Vervet Monkey Alarm Calls

- Seyfarth, Cheney & Marler (1980) *cont.*
  - ▸ Second call, or appearance of predator does not lead to further repetitions of the call
  - ➡ Further calls would not be adding new information in these instances
  - ➡ Calls have ***meaning*** and display ***intentionality***?

Vervet Monkey Alarm Calls

- Cheney & Seyfarth (1985, 1991)
  - Varied visible company
    - Mother more likely to give an alarm call when own offspring present than other young

    ➡ ***NOT*** Zero Order intentionality (not a reflex)

    - No relationship to knowledge of target (agent knows this via target gaze direction)

      Target ***cannot*** see danger: receives alarm call
      Target ***can*** see danger: receives alarm call

    ➡ ***NOT*** 2nd Order intentionality (unrelated to target's beliefs)

Vervet Monkey Alarm Calls

- Seyfarth & Cheney (1993, See Pearce)
  - Other species of ape threaten infants,
    only infants make baboon alarm call
    - Threatening ape hidden in enclosure in full view of mother
    - ▸ Young vervet monkey entered, mother failed to give warning
      - ➡ Mother failed to understand situation,
        failed to display adaptability to unusual situation

- ➡ Vervet communication: 1st Order intentionality at the very best, aware of other monkeys, but not their mental states

- ➡ Arguments against even 1st Order (Burghardt, 1985)

Limits to Natural Communication

- Many 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 animal calls show audience effects

  Chickens
  Ground squirrels
  Jungle fowl

➡ In all cases, same problems to answering key questions:

Do calls have meaning?
Do calls indicate intentionality?

Limits to Natural Communication

- Cheney & Seyfarth (1992)
  - Precise definitions are possible for human language because we have many words
  - ➡ Even if Vervet calls have meanings, hard to pin these down

    Would 'lion' warning still be given if no trees present?

- Seyfarth & Cheney (2003)
  - Communication and intentionality limited because animals cannot attribute mental states to others
  - ➡ Others' beliefs unknown, so cannot try to change them

Limits to Natural Communication

- Pearce (2008)

  ➡ No animals interact with sufficient complexity to imply anything equivalent to human language

  [Not even dolphins, insufficient space for this topic]

  - Language has biological and developmental ‘baggage’

  ➡ No animals interact with sufficient complexity to ***need*** anything equivalent to human language

  ➡ Simple signals suffice in vast majority of circumstances

➡ Natural communication reveals no hidden capacity for intelligent behavour not already revealed in Lectures 7/8

9.3 Taught Animal Language

- Natural communication difficult to study
  - Lack of control of acquisition
  - Unclear meanings of utterances

➡ Is is possible to teach animals communication methods that will avoid these problems?

➡ For example, can primates be taught human-like grammatical language and display understanding?

- Aitchison (1989), Pearce (2008), Pinker (1994), Reznikova (2007), Wallman (1992)
- ***Caution, entrenched ideologies and vested interests zone***

The Ape Sign Language Projects

- Behaviourism roots
  - Any animal can learn language if correct reinforcement
  - Humans lucky, stumbled on language by accident?
- Initial projects simply tried to bring up chimpanzees in human surroundings, no language learning
  - Attempts to teach chimpanzees vocalisations also failed (physically impossible)

➡ Apes very dexterous, teach them sign language?

The Ape Sign Language Projects

- Washoe – Chimpanzee (Gardner & Gardner, 1969)
  - Teaching
    - Surrounded by humans signing
    - Intention: signs acquired by observation/imitation; failed
    - Shaping ineffective, moulding eventually preferred method
  - Vocabulary
    - Learnt over 30 signs in 21 months
    - 130 in four years until project ended

The Ape Sign Language Projects

- Washoe – Chimpanzee (Gardner & Gardner, 1969) *cont.*
  - Combination
    - Two/three sign combinations frequent,

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

  - Grammar
    - Little evidence for learning importance of word order, but not given rigorous training

      GO SWEET = **SWEET GO**

    - Claimed that word order became more regular with time, reached level of a human 2 year old

The Ape Sign Language Projects

- Washoe – Chimpanzee (Gardner & Gardner, 1969) *cont.*
  - Understanding and inference
    - Able to give correct (noun) sign when shown slides
    - ***Generalised:*** **MORE** initially used when being tickled, then used in context of other games and food
    - ***Overgeneralised:*** **FLOWER** anything with a strong smell
  - Culture
    - ***Education:*** Evidence of teaching signs to other chimpanzees after training program ended

➡ Clear evidence for human-like language development and production?

The Ape Sign Language Projects

- Koko – Gorilla (Patterson)
  - Vocabulary
    - Over 600 signs claimed
  - Combination
    - Longest sequence

PLEASE MILK PLEASE ME LIKE DRINK APPLE BOTTLE

  - Grammar
    - No claims for grammatical structure

The Ape Sign Language Projects

- Koko – Gorilla (Patterson) *cont.*
  - Understanding and inference
    - ***Creativity:*** combined signs if appropriate one not taught

      EYE HAT *(mask)*
      WHITE TIGER *(zebra)*
      COOKIE ROCK *(stale roll)*

    - ***Higher order:*** claims for metaphors, puns, insults, lies

      signed **RED FROG** *for frog [an error, surely?]*

➡ Koko is claimed to have an IQ of 85-95

The Ape Sign Language Projects

- Nim Chimpsky – Chimpanzee (Terrace, 1969)
  - Similar training and achievements to Washoe
  - Combination
    - Plenty of multi-sign combinations,longest one 16 words

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

➡ Additional signs for emphasis rather than for information

The Ape Sign Language Projects

- Nim Chimpsky – Chimpanzee (Terrace, 1969) *cont.*
  - Grammar
    - Word order was statistical rather than rule driven

      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 instances learnt rather than category rules

The Ape Sign Language Projects

- Nim Chimpsky – Chimpanzee (Terrace, 1969) *cont.*
  - Understanding and inference
    - ▸ Proportion of signs that were imitations ***increased*** with time
    - ➡ Language being adopted for obtaining rules and gratification, learnt that imitation was a useful strategy

➡ Despite initial support, Terrace skeptical of claims that apes able to learn language in the human sense

The Ape Sign Language Projects

- Interim evaluation: Sign language
  - Seidenburg & Petitto (1979)
    - 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

The Ape Sign Language Projects

- Interim evaluation: Sign language *cont.*
  - Sebeok & Umiker-Sebeok (1980)
    - Many studies badly implemented
      - Unintended cues by experimenters
      - Understanding versus accidents/researcher bias?

➡ Anecdotal evidence cannot offer any conclusions about language learning ability, data/analysis needed

The Ape Sign Language Projects

- Interim evaluation: Sign language *cont.*
  - Why the emphasis on ***can apes learn grammar?***
    - Cornerstone of a futile debate
      - Chomsky: humans uniquely programmed for language, have an innate ability to learn grammar
      - Opponents: if apes can learn language, no special innateness necessary to account for human language
    - Useful for understanding animal intelligent behaviour
      - Sequential changes to word order affect meaning
      - Demanding of cognitive capacity to recognise, learn, use (compare with animal intelligence tests, Lecture 7)

➡ Apes learnt to solve (some) problems, but grammar learning is at the limits of available cognitive capacity

The Ape Artificial Language Projects

- Apes learn sign language with difficulty
- Meaning/origin of gestures problematic
- Ape ability to learn grammar inconclusive

➡ American Sign Language too 'organic'?

- Lack of systematicity makes signs harder to learn?
- Does not support grammar learning well?
- A more constrained and regular language necessary?

➡ Teach apes artificial language expressed using symbol tiles or a keyboard?

The Ape Artificial Language Projects

- Sarah – Chimpanzee (Premack, 1971)
  - Teaching
    - Taught to manipulate magnetic tokens, varied in colour and shape

      MAUVE TRIANGLE = *apple*
      BLACK T-SHAPE = *the colour yellow*

    - Shaping used for training
    - Training/evaluation sessions lengthy/drilled, not rewarded if made mistakes
  - One chimpanzee from four managed to learn the system

The Ape Artificial Language Projects

- Sarah – Chimpanzee (Premack, 1971) *cont.*
  - Vocabulary
    - Learnt over 100 symbols denoting colours, shapes, sizes and logical relationships such as *same*/*different* and *if … then …*
  - Combination
    - Could understand complex instructions (e.g. six symbols) but did not create own equivalents
  - Grammar
    - Could learn that strict order of symbols important for following instructions or obtaining reinforcement

The Ape Artificial Language Projects

- Sarah – Chimpanzee (Premack, 1971) *cont.*
  - Understanding and inference
    - Able to follow complex instructions

IF APPLE THEN CHOCOLATE

(take apple to get chocolate)

SARAH INSERT BANANA PAIL APPLE DISH

QUERY CUP EQUAL SPOON

- *Displacement:* told **BROWN IS COLOUR OF CHOCOLATE**, pointed to brown patch, no chocolate in view

The Ape Artificial Language Projects

- Lana – Chimpanzee (Rumbaugh)
  - Teaching
    - Giant computer keyboard, coloured shapes stood for words
    - Request food and drink, communicate with a trainer
    - Shaping used in an attempt to teach grammar
  - Grammar
    - Learnt grammar poorly, trial & error was main strategy, many retries, eventually rote learning

The Ape Artificial Language Projects

- Lana – Chimpanzee (Rumbaugh) *cont.*
  - Understanding and inference
    - ***Generalised:*** **MORE** initially used in specific instances, then use spread
    - ***Creativity:*** *cucumber* named **BANANA WHICH IS GREEN**
  - Culture
    - ***Collaboration:*** other chimpanzees learnt to use system, *Austin* and *Sherman* could use keyboard to request tools from each other for problem solving tasks

The Ape Artificial Language Projects

- Kanzi – Bonobo (Savage-Rumbaugh, 1990)
  - Teaching
    - Miniature version of computer keyboard, coloured shapes stood for words
    - No initial training, began spontaneous use of single symbols after observing two years of failed attempts to train mother
    - Training necessary after that to reinforce grammar etc.
  - Vocabulary
    - Over 150 symbols
  - Grammar
    - Eventually could demonstrate some evidence of learning

The Ape Artificial Language Projects

- Kanzi – Bonobo (Savage-Rumbaugh, 1990) *cont.*
  - Understanding and inference
    - If pressed a key for an object, and given a choice, only took named object
    - Speech comprehension good, could follow spoken instructions; claimed to be equivalent to 2½ year old human

➡ Claimed to be the biggest success to date

"ape at the brink of the human mind"

The Ape Artificial Language Projects

- Interim evaluation: Artificial language
  - Wallman (1992)
    - How much did Sarah understand that the symbols had underlying meaning?

      (1) Sessions too narrow, repetitive single formats, slot filling
      - e.g. **SARAH GIVE MARY** _____

      ➡ Most symbols redundant, simple association task

      (2) Painstaking training, step by step, learning/combining
      - **SARAH INSERT BANANA PAIL APPLE DISH**

      ➡ Step by step not needed if genuine understanding?

The Ape Artificial Language Projects

- Interim evaluation: Artificial language *cont.*
  - Wallman (1992) *cont.*
    - Apes are good at learning to learn (see Lecture 7)
    - Apes learnt to respond in certain ways to certain sequences of shapes to receive rewards

➡ Artificial language projects look more extensive logic/learning tasks than communication training

Language or Problem Solving Training?

- Patterson

  “language is no longer the exclusive domain of man”

- Pinker

  “the chimps are highly trained animal acts”

- Clear, repeated pattern of findings
  - Developmental reaches 2½ year old human, then stops
    - Around 150 symbols learnt
    - Grammatical rules learnt only with great difficulty
    - Longer sequences give emphasis rather than information
  - ➡ Not clear that concept of ***meaning*** is acquired

Language or Problem Solving Training?

- What is the language learning significance of 2½ years?
  - Humans: threshold beyond which learning accelerates
  - Apes: developmental ceiling, progression stops
    - Lower cognitive capacity than humans
    - Unlikely to have specialised short term verbal memory
      - ➡ Language learning and use is a very hard task for apes
        - Grammatical rules hard to identify and learn, compare with higher order logic tasks in Lecture 7
        - Sequencing of long word strings difficult, requires cognitive capacity to combine multiple ideas

➡ Cognitive problems for apes stack up insurmountably

➡ Point where language enhances capacity never reached

Language or Problem Solving Training?

- What do apes ***understand*** when they use symbols?
  - Creativity implies knowledge of underlying meaning?
  - ▸ But ape creations rare/anecdotal/accidental
  - ➡ Insufficient data to show that symbols are understood

Language or Problem Solving Training?

- What do apes ***understand*** when they use symbols?
  - Humans ascribing symbol meanings on behalf of apes?
    - Key pressed by Lana to commence requests is named “please” by researchers
    - Repetitive slot filling more like a reasoning task 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 was understood

➡ Savage-Rumbaugh et.al. (1983)
apes understand few, if any, symbols

Language or Problem Solving Training?

- Symbols as concepts, or symbols as tools?
  - Savage-Rumbaugh (1987)
    - Apes are inappropriately taught
    - Apple out of reach, must request apple to obtain it
    - ➡ Ambiguous: symbol for an apple could mean:
      Shape that is equivalent to apple: ***CONCEPT***
      Shape that if chosen results in apple: ***TOOL***

➡ Learning the ***consequence*** of using a symbol is not the same as learning the ***meaning*** of a symbol

➡ Understanding underlying concept of ***meaning*** is cognitively demanding?

Language or Problem Solving Training?

- Symbols as concepts, or symbols as tools?
  - What do apes ‘talk‘ about?
    - Language use as a method to obtain food and gratification dominates massively, even for Kanzi

    ➡ Language = conversational method for obtaining rewards

    - Symbols rarely used for informational purposes, to discuss objects, or simply for the sake of it

    ➡ Lack of human-like interest in language itself

➡ Indicates something more profound than apes simply learning to play the laboratory game

Language or Problem Solving Training?

- Symbols as concepts, or symbols as tools?
  - Human cognitive capacity focused towards ***meaning***
  - Chimpanzee cognitive capacity focused towards ***use*** *[at the expense of **meaning**]*

    Human: ***what is this?***

    Chimpanzee: ***what is the use of this?***

- Good for learning how to use symbols as effective tools
- Bad for deeper-level understanding of language

➡ Focus detracts from cognitive capacity, exacerbates all language learning problems, plus developmental ceiling

Language or Problem Solving Training?

- ➡ Language ability by apes in training studies exactly as predicted from learning/problem solving research
- ➡ If anything, (mis)focused cognitive capacity detracts from ability, *less effective learning than might be expected*
- ➡ Insufficient learning to reach the point at which language yields cognitive enhancement fringe benefits
- ➡ No revealing of hidden untapped mental lives of apes

Postscript: Teaching Other Animals

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

➡ Comprehending language easier than producing language

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

➡ Cognitive capacity focused ***towards*** word-sounds, enhances performance beyond expectations

- See Pearce (2008), Reznikova (2007)

9.4 What Does Communication Reveal?

- Natural communication
  - ➡ Animals who (perhaps) communicate symbolically do so with limited meaning, understanding, intentionality
- Taught communication
  - ➡ Language learning exactly in line with general learning/ problem solving ability/(mis)focused cognitive capacity
  - ➡ How much more is human language ability than high, focused cognitive capacity, and learning ability?
- In a social group, limited communication powers can still be used intelligently

➡ Look for animals exploiting their own strengths, not human strengths (Lecture 10)

Major Sources

- Aitchison, J. (1989). *The Articulate mammal* (3rd edition). London: Unwin Hyman. [Any edition has the most important details]
- Pearce, J.M. (2008). *Animal cognition & learning* (3rd ed). Hove: Psychology Press.
- Pinker, S. (1994). *The Language Instinct*. London: Allen Lane.
- Reznikova, Z. (2007). *Animal intelligence*. Cambridge: CUP.
- Seyfarth, R.M., & Cheney, D.L. (2003). Signallers and receivers in animal communication. *Annual Review of Psychology*, *54*, 145-173.
- Wallman, J. (1992). *Aping Language*. Cambridge: CUP.

References

- Burghardt, G.M. (1985). Animal awareness: current perceptions and historical perspective. *American Psychologist*, *40*, 905-919.
- Cheney, D.L., & Seyfarth, R.M. (1985). Vervet monkey alarm calls: manipulation through shared information? *Behaviour*, *94*, 150-166.
- Cheney, D.L., & Seyfarth, R.M. (1991). Reading minds or reading behaviour: tests for a theory of mind in monkeys. In A. Whiten (ed.). *Natural Theories of Mind*. Oxford: Blackwell.
- Cheney, D.L., & Seyfarth, R.M. (1992). Précis of how monkeys see the world. *Behavioral and Brain Sciences*, *15*, 135-147.
- Gardner, R.A., & Gardner, B.T. (1969). Teaching sign language to a chimpanzee. *Science*, *165*, 664-672.
- Gottfredson, L.S. (2007). Innovation, fatal accidents, and the evolution of general intelligence. In M. J. Roberts (Ed.), *Integrating the mind*. Hove: Psychology Press.
- Meo, M., Roberts, M.J., & Marucci, F. (2007). Element salience as a predictor of item difficulty for Ravens Progressive Matrices. *Intelligence*, *35*, 359-368.
- Miles, H.L.W. (1990). The cognitive foundations for reference in a signing orangutan. In S.T. Parker, & K.R. Gibson (eds.). *Language and Intelligence in Monkeys and Apes*. Cambridge: CUP.
- Pepperberg, I.M. (1990). Conceptual abilities of some non-primate species, with an emphasis on the African Grey parrot. In S.T. Parker, & K.R. Gibson (eds.). *Language and Intelligence in Monkeys and Apes*. Cambridge: CUP.

References

- Premack, D. (1971). Language in chimpanzee? *Science*, *172*, 808-822.
- Savage-Rumbaugh, S. (1987). A new look at ape language: comprehension of vocal speech and syntax. In D.W. Ledger (ed.) *Nebraska Symposium on Motivation* (vol. 35). Lincoln NB.: University of Nebraska Press.
- Savage-Rumbaugh, S. (1990). Grammatical combination in Pan paniscus: processes of learning and invention in the evolution and development of language. In S.T. Parker, & K.R. Gibson (eds.). *Language and Intelligence in Monkeys and Apes*. Cambridge: CUP.
- Savage-Rumbaugh, S., Pate, J.L., Lawson, J., Smith, S.T., & Rosenbaum, S. (1983). Can a chimpanzee make a statement? *Journal of Experimental Psychology (General)*, *112*, 457-491.
- Sebeok, T.A., & Umiker-Sebeok, J. (1980). *Speaking of Apes*. New York: Plenum Press.
- Seidenburg, M.S., & Petitto, L.A. (1979). Signing behavior in apes: a critical review. *Cognition*, *7*, 177-215.
- Seyfarth, R.M., Cheney, D.L., & Marler, P. (1982). Vervet monkey alarm calls: semantic communication in a free ranging primate. *Animal Behaviour*, *28*, 1070-1094.
- Terrace, H.S. (1979). *Nim*. London: Eyre Methuen.

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