PS452 Intelligent Behaviour

Part 3: Intelligent Behaviour in Animals

2) Tools, Puzzles, Beliefs, & Intentions

➲ *What is learnt from interactions with objects?*

- Cognitively gifted or innate meddlers?

Lecture 8:
Tools, Puzzles,
Beliefs, & Intentions

1) **The Cognitivist's Dilemma**

   Often a simple explanation

2) **Natural Tool Use**

   Problem solving in the wild?

3) **Problem Solving in the Laboratory**

- Early work
- Recent studies
- Evaluation

4) **Beliefs, Desires, Intentions**

- Detecting intentional states
- Dennet's *intentional systems* theory

1) The Cognitivist's Dilemma

- Kuczaj & Walker (2006):

❶ Dolphins taught to gather weights to obtain fish, four weights necessary

❷ Leant by *imitation* to carry *individual* weights

❸ Some dolphins spontaneously began to carry weights *simultaneously*

➲ Planning and foresight to obtain food with fewer journeys?

➲ Or learnt associations?

As task progressed:

Weights and food became more and more strongly associated

As weights became more strongly associated, more were carried

➲ Often more than one explanation

➲ *Beware anthropomorphism*

2) Natural Tool Use

- Why are Tools Interesting?

- Beyond our genetic equipment
- Widens our environmental niche
- A key stage in human evolution?
- A key step for evolution of language?
- Advanced use = advanced understanding?

➲ CAUTION: could be genetically programmed in other animals

- NOT can animals use tools?

➲ What does tool use reveal about planning, causal reasoning, intent?

- Intelligent tool use in animals?

➲ Selecting correct tool, modifying tool

- Rare in the animal world

  Kacelnik et al. (2006)
  Pearce (2008)
  Reznikova (2007)
  Visalberghi & Fragaszy (2006)

➔ Woodpecker finches remove/shape cactus spines, probe for insects in tree bark

➔ Egyptian vultures drop stones on eggs to break them, have preferred stone sizes

➔ Sea otters dive for shellfish,
use stones to break shells

➲ One object used for one specific purpose

- Multiple tool use much rarer

➔ Elephants: throw logs, strip branches to swat flies, use grass to clean/close wounds

- More versatility (dexterity?) in monkeys and apes

➔ Chimpanzees > orangutans > gorillas etc.

➔ *Food Extraction*
Stick probes
Chimpanzees (strip) ➔ termite mounds
Orangutans ➔ *puwin* fruit

Leaf sponges (chimpanzees, vervets)

Nut smashers (chimpanzees, capuchins)

➔ *Defence / Aggression*
Objects thrown (many species)
Used to make noises (chimpanzees)

➔ *Intuitive Physics* (gorillas only, rare)
Stick to test water depth
Log to cross water

➔ Equal versatility in corvids (crows etc.)
Stripped twigs/leaves/feathers
➔ insects in tree bark and holes
Shape of implement matches function

- Kacelnik et al. (2006): Chimpanzees and New Caledonian crows are unique:

  Frequency: universal between populations

  Diversity: different tools/different function

  Complexity: tools are manufactured

➔ But crows and chimpanzees who are isolated from birth still use tools

⮊ Genetic programming, clever, or lucky?

What does this mean?

- Ingenious use, but what are origins?

❶ Imitation and trial and error?

❷ Insight and understanding?

❸ Both?

- *Insight:* understanding the properties of objects in order to reason to a solution

  Reznikova (2007): must be *sudden* and no relevant *past experience*

➲ Periods of reflection sought/highlighted

➲ Objects never used in this way before

- Incredibly harsh definition
- Obsolete: *Behaviourists vs Gestaltsts*

➲ Pearce (2008): false dichotomy

➲ Even so, observational studies only go so far

❶ No control over upbringing etc.,
so cannot identify origins of tool use:

❷ No control over opportunities/needs

➲ Cannot give clear overview
of relative cognitive ability:

- Capuchins (Visalberghi & Fragaszy, 2006)
- In the wild: Destructive foragers,
seek hidden food

➔ Little tool use

In the laboratory: Attention-focused on
manipulating objects

➔ Considerable tool use

Tree-living limits manipulation
[Holding on, dropping, fewer objects]

Observation also difficult

Prolific food reduces need

➲ Laboratory needed to foster behaviour

➲ Problem: few opportunities for lab research

3) Problem Solving in the Laboratory

Early Work

Pearce (2008)
Reznikova (2007)

- Thorndike (1911): problem solving =

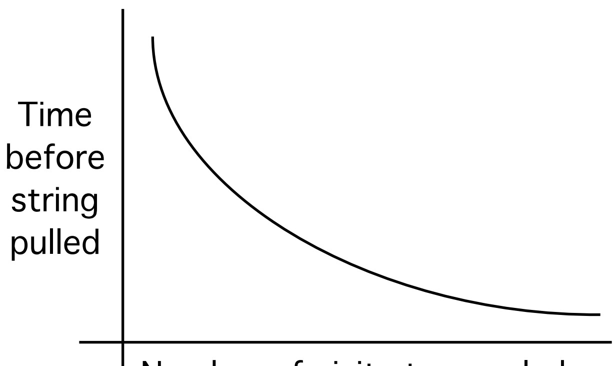
① Random trial and error behaviour

② Accidental success reinforced, response *strengthened*, more likely in future

➲ Zero inference/understanding

- Animals escaping from *puzzle boxes*

➔ As predicted, *gradual* improvements, smooth learning curves



➲ Trial and error = only source of solution

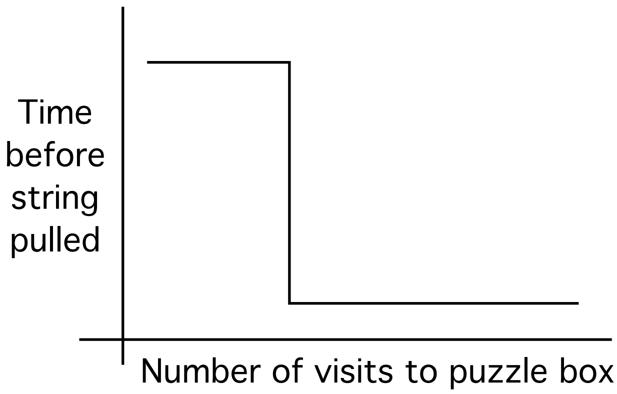
- Approach often criticised

❶ No opportunity for reasoning/insight

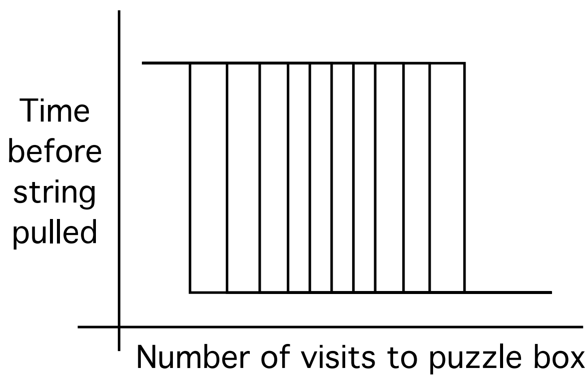
➲ Impoverished situation ➔ impoverished behaviour

❷ Woodworth (1938): considerable differences between animals

➔ Individual learning curves discontinuous



➲ Noise, or differences in cognitive ability?



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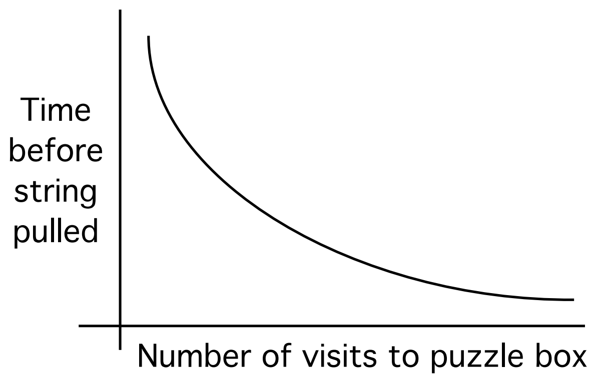

- Köhler (1920s):

  Young chimpanzees caught in wild
  [no control over upbringing]

❶ Food in cage, high up, out of reach

➔ Initially tried jumping

➔ One ape gave up, after a pause,
moved a box, stood on it

❷ Food out of cage, slightly out of reach
[Various objects including sticks inside]

➔ Stretch arms through the cage

➔ One ape gave up, after a pause,
picked up a stick and reached for food

➔ Varied in skill; some tried to use food dish

- No random behaviour

➔ Pattern: failure ➔ retreat ➔ solution

➲ Not fully in support of Thorndike?

- ❸ Food out of cage, greater distance

  [Sticks could be slotted together]

- ➔ One ape tried reaching with a single stick

  Gave up, tried throwing a stick outside cage and pushing it with another stick

  Later, while playing with sticks, two accidentally joined together

  Immediately ran to side of cage and reached for food

- ➲ Joining sticks was luck, but at least some apes understood distance

- Star performer problem

➔ Best apes: repeated attempts at novel (creative?) solutions

➔ Worst apes: complete failure, e.g. to take stones out of heavy box

- What do individual differences mean?

➲ Learning/ability ➔ problem solving, NOT innate processes

➲ Must interpret failures and superstars: Chabris (2007) *range of cognitive ability*

- Previous history of apes unknown
  Able to play in laboratory

➔ Birch (1945): Chimpanzees bred in captivity only retrieve food after experience with sticks

➲ Successful use = past reinforcement?

➲ Problem solving behaviour: part trial and error, part memory, part understanding?

- Epstein, Kirshnit, Lanza & Rubin (1984): Are chimpanzees special? **[bad question]**

❶ Trained pigeons to push a box towards a spot randomly placed on a wall

❷ Trained same pigeons to climb on a static box to peck at a plastic banana

❸ Novel situation: no spot on wall, box not under banana

➔ Pigeons pushed box under the banana and climbed upon box to peck at it

➔ Fastest performance better than apes

➲ Learning necessary, but no trial and error

- Even sophisticated tool use is still learned associations??

➲ Pearce (2008): Pigeons learned to push box towards food association (spots/bananas)?

➲ Reznikova (2007): Apes often gathered inappropriate tools! Associated with food?

- Behaviour is interesting because it is ***goal directed***

➔ Pigeons applied a *novel combination* of learnt behaviours to attain a goal

➲ *Not* insight but still interesting

➲ Can all species link novel sequences?

- Behaviours highly salient for the pigeons

➲ What if irrelevant behaviour taught too?

- What are the control processes necessary to select and co-ordinate various individual sequences of behaviour?

➲ *Intelligence = selecting a sequence of behaviour components to attain a goal?*

➲ *Cf. humans: intelligence = sophisticated* ***goal management***

Modern Work

Kacelnik et al. (2006)
Pearce (2008)
Reznikova (2007)
Visalberghi & Fragaszy (2006)

- Problem solving tasks where the solution is 'visible'

➔ Causal understanding if we observe:

❶ Early solution

❷ Appropriate behaviour if task is modified

➲ *What are the limits of understanding?*

➲ *Insight* = obsolete word?

Pulling tasks (zero order)

[order = no of simultaneous elements]

- Pull string or cloth to obtain food

  Do not pull if food not visibly linked

➔ Failures:
Digger wasps (on prey)
Elephants (despite widespread tool use)

➔ Success:
Most apes/monkeys (not all individuals)
One-year-old children
Many birds (great individual differences)
Kea (parrot): correct string even if crossed

➔ Difficult to train:
Cats, rats

➔ Socialised animals (dogs, talking parrots):
Attempt to cue behaviour in humans

➲ Many animals: causal reasoning

➲ Failures interesting?

Stick tasks (first order)

- Use stick or similar to draw in food

  May need choice of appropriate stick

➔ Apes and monkeys perform well

➔ Good performance from certain corvids
Kacelnik et al. (2006, New Caledonian Crow):
Can select appropriate length even when tool/reward not simultaneously visible
Can select appropriate rigidity
Can create hooks from wire without trial & error

➲ Task penalises poor dexterity

➲ Success indicates causal reasoning

➲ Lack of success: ???

Tube tasks (first order)
Tube tasks with trap (second order)

- Push food through tube e.g. with stick

  Choose correct direction to avoid trap

➔ Chimpanzees/other apes (best performers):
Basic task: can reshape, unbundle, without trial and error

Trap tasks:

can learn that 'nearest opening' strategy loses food,

cannot react to trap inversion

➔ Capuchins:
Basic task, can solve
Poor at reshaping, unbundling
Trap tasks: similar to chimpanzees

➔ Corvids:
Can choose diameter, unbundle, reshape
Trap tasks: similar to above

➲ Reaching the limits of causal reasoning?

Evaluation

- Individual differences problematic
- ➲ Best performers reported, the lucky ones?
- ➲ Pass/fail = lucky choice of subjects

- Poor performance is revealing:

  No understanding

  [Köhler: *Bad mistakes*, e.g., pulling *down* on stick hanging from loop]

  Accidental solutions

  Failure to refine solutions

  Negative transfer/set effects
- ➲ Success/flexibility = exception not the rule

- In modern work, *causal reasoning* can be demonstrated, and its limits.
- ➲ Same species pattern for tool use and learning?

The special case of corvids?

- Star performances (Kacelnik et al., 2006)

➔ Chose rigid rake over flexible one, exposed to rakes before, but not used for dragging

➔ Spontaneously created hook from wire, never encountered wire, or similar, before

➲ *As good as monkeys and even chimpanzees, sometimes better*

- Cognitive capacity out of the ordinary?

➔ Good working memory/cognitive capacity?

➔ Good rule learning/problem solving

➲ Good planning/causal reasoning

Problems or profundities?

- The best tool users/learners/problem solvers/causal reasoners are different

❶ Few predators, attentional priorities differ
➲ Deliberate problem solving = luxury
❷ Best manipulation skills (beaks, arms)?
➲ Physical opportunities limited for most
❸ Innate interest in objects (twigs, containers)
➲ Potential tools must feature 'on the radar'

- Superior skills are an illusion,
  the product of innate predispositions

➲ But all of the above are particularly true for humans too

- Stenning & Van Lambalgan (2007):

➲ Sequencing of complex actions requires planning, a precursor to language in humans, a marker for advanced cognition

Three possibilities

- Learning, tool use, problem solving and associated causal understanding …

❶ Result from innate domain specific skill

➲ Other animals have different skills

❷ Result from enhancement/lack of distraction of domain general ability by innate attentional preferences

➲ Other animals may have similar domain general ability, but lack positive bias, or even have innate detractions

❸ Result from higher than typical domain general ability, which redirects interests

➲ Intelligent enough to know what problems are, permanently on the lookout for potential solutions

➲ ❶, ❷, or ❸ depend on the species?

4) Beliefs, Desires, Intentions

McFarland (2008)

- Humans appear to have plans, goals, beliefs, desires, *intentions*

➲ These *may* guide our behaviour

- Searle (1980)
- Computers have *the wrong hardware*, can never be *intentional*

➲ Animals have *the right hardware*, can their brains be intentional?

- When a chimpanzee chooses a stick, does it *believe* that it will solve the problem?!

➲ Failure ➔ appearance of surprise/distress

- Understanding complex behaviour:
  Do we need intentional concepts?

- Beware *architectureism*

➲ A cat waits at a food bowl, does it *desire* food and *believe* this will be provided?

➲ Computer plays chess, does it *desire* my defeat and *believe* that it can win?

- N.B. is our behaviour really causally determined by intentions?

➲ Causality of intentions illusionary?
  Product of behaviour not the cause?

Detecting Intentional States

Heyes and Dickinson (1993):

- Testable predictions needed
- ➲ Do things with intentions behave differently from things without them?

- Causal accounts of intentions assume rationality
- ➲ Cannot predict that beliefs/desires will affect behaviour for irrational entities

- Enormously difficult to determine
- ➲ Thermostat: goals and control, but not intentions? Computer chess, Civilization game

Causal beliefs?

- Do beliefs cause behaviour?

➲ Put animal in a world where belief does not apply, changes behaviour?

- Rats taught to press a lever to obtain food

➔ Stop pressing if ceases to be necessary

➲ But extinction explained by behaviourism

- When chicks approach food bowl, do they believe that approach ➔ access to food?

  Food bowls raced away when approached; approached chicks when they walked away

➔ No change to behaviour, chased food away

➔ Other animals (e.g. rats): hard to learn that approach may cause failed goal attainment

- **EITHER** No beliefs about approach, automatically attempt to obtain food

  OR Possess beliefs, no causal properties, could not prevent physical response

  OR Defective beliefs about approach insufficiently flexible to change

- Approach behaviour may appear to be non-intentional in some cases

- *BUT*
- Many human beliefs resistant to change?

Causal desires?

- Do desires cause behaviour?

➲ Changed desires should change behaviour

- Difficult to manipulate desires
- Difficult to show that desire is different from motivation

- Rats taught to obtain saccharine solution Induce nausea, taste is remembered

➔ No difference in initiation compared with control rats

➔ Reduced drinking after solution tasted

➲ Rats expected solution to quench thirst?

➲ Reminded of nausea when they tasted it had their desire reduced?

- McFarland (2008): Behaviour can easily be simulated by a 'robot rat'

➲ Effects too subtle to test?

Dennet's Intentional Systems Theory

- Effects are too subtle to reveal with simple behaviour in simple situations?

➲ Communication and social behaviour sufficiently complex to test for intentions?

- All-or-nothing unlikely, framework needed

➲ *Intentional Systems theory*

- Dennett (1983): Some animals may be **treated** as *intentional systems*

➲ *Intentional stance:* behaviour of a system can be predicted by attributing intentions

➲ These need not be real, just a convenience

- Classify intentionality level by behaviour

➔ Determine highest degree of intentionality that an organism can display

➲ Predict complexity of behaviour in future?

➲ More effective than behaviourist stance?

- E.g. vervet monkeys give different alarm calls according to which predator is seen

  Lion alarm call given …

0 Zero order: Reflexes/associations

➲ Lion call automatically triggered by lion

"Aaaaaagh"

1 First order: Agent desires to change the behaviour of target, not beliefs

"A first order intentional system has beliefs and desires (…) but no beliefs and desires about beliefs and desires."

➲ Monkey desires others to climb to safety

"Climb"

2 Second order: Agent desires to change the beliefs of target, now *knows about* beliefs and desires of target

➲ Monkey desires others to believe that there is a lion (and hence to climb trees)

"Lion"

3 Third order: Agent desires to change the target's belief about agent's beliefs/desires

➲ Monkey wishes others to believe that it wishes them to climb trees

- More examples:

  [**A** is agent, **T** is target]

0 Automatic statement: e.g. pain, slogans

"ouch" , "fire"

1 Change **T** behaviour (*an order*):

"Get out of this building"

2 Change **T** beliefs (*a warning*):

"This building is on fire"

3 Change **T** beliefs about **A** beliefs (*an excuse*):

"I left the lecture early yesterday because I thought the building was on fire"

4 Change **T** beliefs about **A** beliefs about **T** beliefs (*an accusation*):

"I don't think you really thought that the building was on fire yesterday, I think that you were looking for an excuse to leave early"

5 Change **T** beliefs about **A** beliefs about **T** beliefs about **A** beliefs (???):

"I want you to know that I am fully aware of just how gullible you think I am for being fooled by that fire alarm prank yesterday"

6 Change **T** beliefs about **A** beliefs about **T** beliefs about **A** beliefs about **T** beliefs (!!!):

"I never realised that you knew I had evidence to show that you didn't really believe that the building was on fire yesterday"

➲ Dennett: human limit around 5/6 order

- Intentionality level = empirical question
- How intentional are Vervet Monkey alarm calls?

❶ Always given even when no others nearby, definitely zero order

❷ If only given when others present, at least first order intentionality?

➲ But still could be a complicated reflex?

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

➔ More likely to give alarm calls when own offspring present than only others present

➲ Not an automatic response,
otherwise no target effects

➔ Calls *NOT* altered by the ***known*** (gaze direction) knowledge of targets

➲ Unlikely that vervet communication is more than first order?

- Do we have another intelligence test?

➲ Only if genuine classifications possible

- What sorts of behaviour might ascend the intentionality scale?

➲ Deception, skilled communication?

➲ ***Back to the Turing Test?***

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