Alien Intelligences: The Minds of Other Animals
CS 1 - Dr. Christine Johnson

**Comparative Cognition** aims to understand the nature of “mind” via across-species studies that ask, for example…

What is it that minds do? What are they for? One answer: They create “Realities”

Reality is determined by the range of perceptual distinctions that a species can make, and by its repertoire of responses.

Consider the Sea Slug (a very alien creature…)

It’s perceptual systems “carve up the world” into relatively few categories:
- dark/light, good/bad chemical gradients, stimuli that poke (bad) or can be eaten or mated (good) - little else!
- Its motor repertoire is likewise limited - it can move forward, backward, contract, engulf objects (preferably food) & mate.

Contrast this with the **Dolphin** (only somewhat less alien…)

Via echolocation, it can discriminate millions of subtle distinctions – i.e. it *hears* the shape & substance of remote objects.
- e.g. Can read returning echoes from muscle, bone, air sacks of predator, prey or conspecifics
- e.g. Can tell ball-bearing aspect that varies by only ~ at 50m

Dolphin also has a complex repertoire of social signals, classifies others as kin, friend, foe, bully, reciprocator, etc.

**THUS:** Each of the above inhabit the *same environment* but very different “realities”

Or, consider **Primates** (our family) – The reality we create is likewise constrained by our species-specific capacities
- e.g. Primates highly visual, Forward facing eyes => binocular disparity for good depth perception for locomotion thru trees and (like in other predators) for catching fast moving insects
- e.g. Have high visual acuity (detailed) & color perception, for detecting ripe fruit, subtle social signals
  - (But not all colors! e.g. “Black, white & grey” sea gull is also UV colored – we can’t see it but they do!)
- e.g. Opposable thumbs, for object manipulation, tool use & ultimately, in our case, a complex material culture!

**Intelligence** - The above approach suggests possible criteria for comparing “intelligences”

- i.e. Level of complexity of the reality a given creature creates - based on range of possible interactions between its perceptual distinctions and repertoire of responses
- and on the *flexibility* the animal exhibits in those interactions

**General Learning Principles**

There are some general learning principles that seem to apply to all species (sea slugs, dolphins, monkeys, humans…)

For example, all natural learning systems (i.e. animals) appear designed to detect, represent, and use **Event Correlations**

That is, when two events reliably co-occur in the animal’s experience, it can use the occurrence of Event 1 to predict the occurrence of Event 2

Lab example: “**Pavlov’s Dog**”: Famous classical conditioning experiment
- Pavlov rang bell just before presenting (drool-producing) food. In time, bell alone would trigger dog to drool

Modern interpretation: Dog learned correlation between E1 bell & E2 food;
- Dog’s salivation to bell is evidence of its expectation/prediction of E2

Naturalistic example: Worm-eating bird learns positive correlation between rain (E1) & worms coming to the surface (E2)
- i.e. It pays to invest in searching ground for worms after rain
- Bird can also learn *negative correlation* between sunshine (E3) and worms coming to the surface (E2)
- i.e. It does not pay to look for worms on sunny day

**BUT** - How can we determine if latter case is, instead, simply a lack of learning? **ANSWER:** Retardation

Train: When bird exposed to red light (E3), pecking at food dispenser delivers no reinforcement (no E2)
- Test: Change rules - red light now does predict food available (E3 now predicts E2)
- Result: Bird takes longer to learn new correlation than it would if it had never been through original “training”

Interpretation: Bird’s learning is retarded since it first had to “unlearn” negative correlation (E3 predicts no E2)

**Species-Specific Learning Constraints**

**BUT** - there are some important exceptions to above that reflect species-specific ecological demands on learning. . .

For example, for most species, a “**Win-stay/Lose-shift**” protocol is best

- “Win-stay” = Perform X, get reinforced, continue to perform X
- i.e. If E1 (X) positively correlates with E2 (food), do E1 to get E2
- “Lose-shift” = Perform X, don’t get reinforced, don’t continue X
- i.e. If E1 negatively correlates with E2, don’t do E1 to get E2

**BUT**, if attempt to train a **Hummingbird** to “Win-stay”, very difficult!
- Prefers “Win-shift” = Perform X, get reinforced, don’t do X again!
- Seems baffling until consider Hummingbird **Ecology**
  - In wild, hummingbird drains all nectar from each flower it visits. So, it never pays to “Win-Stay”!
For most species, for most situations, **Temporal Contiguity** promotes learning
That is, event correlations are best learned when E2 follows E1 **closely in time**
e.g. Ring bell an hour before food served, dog unlikely to learn correlation
BUT, **"Taste Aversion Learning"** in Rats violates this rule.
- Rat exposed to novel food (E1), gets sick (E2) (from tasteless lithium chloride, administered by researcher)
  - if gets sick 1-many hours later, will **not** eat that food again i.e. develops "Taste Aversion"
  - if gets sick immediately, will eat that food again (no aversion)
So, learning new taste + negative reinforcement correlation does NOT show "normal"E1-E2 timing pattern,
since, in the wild, sickness from bad food would only occur after delay!

So, just by looking at temporal relationships between what goes in (stimuli) and what comes out (responses),
in an ecological framework, we can go a long way toward understanding comparative cognition.
But, traditional "Behaviorist" psychology, which focused entirely on Stimulus/Response relationships,
considered the Mind (of human and nonhuman animals) a "Black Box" i.e. opaque, not accessible to scientific scrutiny
In contrast, more contemporary "Cognitivist" models assume that there ARE justifiable inferences that can be made about
what’s in the box”, based on observable behavior...
That is, Cognitive Scientists study the **Mental Representations** that animals form. Such as –

**Cognitive Maps** e.g. a Rat in a “Plus” maze
- Train: Always start in arm A, food always in arm B - Soon proficient. - Test: Start in arm C.
- Result: On first try, turns right (to arm B) even the correct response during training was turn left (from arm A to arm B)
- Interpretation: Rat not just learned “run forward & go left” but instead has formed a “Cognitive Map” of the maze
- Similarly, in a much more complex maze, with several dead-ends, once the animal can efficiently run from start to finish...
- Experimenter removes a barrier (e.g. end of path 4) that the rat notices while running down a later path (e.g. path 11)
  - On the very next trial the rat will take the SHORT CUT now available to it!
  - It could only do this if it had developed a compete Cognitive map of the entire maze during its learning phase

**Prospective Encoding** e.g. in Pigeons
Train: Present color, remove, pause, present vertical and horizontal lines
  Reinforce for pecking Vertical after Blue, Horizontal after Red. Repeat until response is highly reliable
Test: On Blue trial, if briefly present Red immediately after Blue, disrupts performance (pigeon often pecks Horiz).
  But, if briefly present Red after pause (just before present lines) does NOT disrupt performance (pecks Vertical).
  If briefly present Horizontal lines immediately after Blue, does NOT disrupt performance (pecks Vertical).
  But, if briefly present Horizontal after pause (just before choice lines) does disrupt performance (often pecks Horiz)
So, Color disrupts performance early in pause but Lines disrupt it later.
Interpretation: First, pigeon holds representation of color in active memory but then it generates a representation of the line stimulus it is expecting (i.e. the one it is “prospecting for” - thus “Prospective Encoding”)

**Symbol Use** e.g. by Primates
We can train a chimpanzee to associate arbitrary symbols (e.g. numerals) with aspects of its environment (e.g. quantities)
  - Once associations established, without further training they can correctly sum multiple sets of (up to ~10) objects
    (e.g. 3 oranges + 2 oranges = “5”) OR multiple numerals (e.g. “3” + “2” = “5”)
This proficiency with symbols also affects their performance on other cognitive tasks – e.g. the “Greedy Giveaway Task”
  - Chimp is shown 2 diff size piles of M&Ms. The first pile they point to is given to other chimp, they get remaining pile
  - Chimps cannot seem to resist pointing to bigger pile first (even though repeatedly frustrated when it is given away!)
  - BUT, if numerals are associated with the two piles, they CAN point to the smaller numeral (and get the bigger pile!)
  - So, the symbolic representation of the size of the piles seems to provide the opportunity to “think twice”, be strategic

**Self Concept** e.g. in Primates and Dolphins.
  e.g. **Mirror Studies** – done with (relatively smaller brained) monkeys and (larger brained) apes
    - Animal is first exposed to mirror for a time, then it is removed
    - Animal is then anesthetized and its forehead is marked with paint
    - When it wakes, it is watched to see if it detects the paint (not) then re-exposed to mirror
    - RESULTS: Monkeys threaten weird-looking “other monkey” they see
      Ape groom themselves to remove paint
    - INTERPRETATION: Only apes have a "self concept" that allows them to recognize their own reflection as themselves
BUT, some researchers have attempted this same study with Dolphins!
  - i.e. Mark the animal, expose it to a mirror etc. –
  - What do they expect it to do??!!?? Can’t groom mark... Even when they can see mark, do nothing to remove it...
  - Clearly this is NOT an **ecologically valid, species-appropriate** test for a dolphin...

How would YOU determine if a dolphin has a self-concept....?!