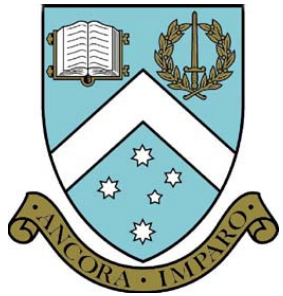

CSE468
Information Conflict

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Lecture 07

The Evolutionary Nature of Information Conflict

Reference Sources and Bibliography

- **References:**

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Information Conflict vs Evolution [Kopp/Mills]

- **Hypothesis (1):** *Information Conflict can be shown to be a very fundamental survival technique which has been and is widely used by biological organisms of unusually diverse species.*
- ***Why is this so?***
- Energy, material, time and safety are all scarce resources that are required by biological entities.
- The need for each of these can be reduced by structural changes in a biological entity which effectively encode more efficient methods of achieving reproduction.
- Biological entities which acquire this information become more numerous.
- The body of each biological entity is a record of information about the environment which evolution has succeeded in encoding in the body.

Information Conflict vs Evolution (2)

- Broadly, to exploit information to effect a change in the surrounding environment that information must be applied against an entity which is unstable or metastable.
- Consequently, a small amount of energy can effect a large change.
- The most unstable entity in the environment of any biological entity will be other biological entities.
- These form a resource of enormous potential to an evolving species.
- *A priori we could not expect this resource to be ignored.*

Information Conflict vs Evolution (3)

- Many species have sensors to detect food and predators.

1. If food is fast enough it can run away;
2. but if not, then it can hide, so as not to be seen;
3. it can pretend to be a poisonous insect;
4. It can spit in the eyes of the predator.

- These very common behaviours cover the first three of the canonical strategies explicitly.
- Examples of subversion are also very common, but often require a more subtle examination to detect.
- Compound strategies are used very often in nature, and thus careful analysis is important.

Demonstrating Generality (1)

- To demonstrate the generality of Hypothesis (1), it is necessary to find a set of examples which meet the following criteria:

1. *The species employs one or more than one of the four canonical strategies to aid in its survival.*
2. *Multiple species which are not closely related, and preferably exist in diverse environments, employ the same subset of the four canonical strategies to aid in their survival.*
3. *Closely related species exist to the examples found, which do not employ any of the four canonical strategies to aid in their survival.*

Demonstrating Generality (2)

- Evolutionary theorists argue that specific features in a species which improve its probability of individual survival and reproduction will be propagated, at the expense of features which impair the probability of individual survival and reproduction, refer (Dawkins, 1996) and (Wills, 1989).
- A set of species which share the common attribute of using a set of the four canonical Information Conflict strategies, yet are not closely related biologically, could only have developed the use of this set of strategies under evolutionary survival pressure, as the absence of a near common ancestor denies the immediate inheritance of the trait

Degradation in Nature

- Degradation as a strategy is mostly manifested as camouflage, intended to prevent visual detection of the species in question.
- Herbivores employ this strategy to evade predators.
- Predators use this strategy to support ambush attacks, especially where the predator lacks the speed or persistence of the prey.
- There are very few species where camouflage is not the predominant strategy used to aid survival.
- The overwhelming number of instances which satisfy the criteria for Hypothesis (1) make an irrefutable case for degradation as an evolved survival aid.

Degradation in Nature - Examples

- **Orthoptera - Grasshoppers, Crickets and Katydids:** this order is large with »20,000 species cited. Most of these are exceptionally well camouflaged in colour, texture and frequently also shaped to blend against their habitat and evade predators. Many species have camouflage which is uniquely adapted to hide against dead leaves, bare dirt, grasses, stones and green foliage.
- **Mantodea - Mantids:** these predators lack agility and hunt primarily by ambush, therefore the effectiveness of their camouflage will reflect directly in how many meals they have. Species which have remarkably effective camouflage are the Brazilian *Acanthrops falcataria* which hides as a dead leaf, the Indian *Humbertiella ceylonica* which hides against tree bark - a very wide range of mantids hide against green foliage.
- **Phasmatodea - Stick and Leaf Insects:** these slow moving herbivores have evolved camouflage in their shape, colour, texture and movement, to hide from predators by resembling dead or live foliage.

Degradation in Nature - Examples

- **Arachneidae - Spiders:** from the perspective of camouflage, the most interesting spiders are the tree and ground dwelling ambush predators, such as the tarantulas in the Americas, huntsmen in Australia and baboon spiders of Africa.
- **Orectolobidae - Wobbegong Sharks:** these sluggish bottom dwelling members of the shark family employ very effective camouflage to evade larger predators, and to facilitate predation upon smaller species.
- **Soleidae, Pleuronectidae and Bothidae - Sole and Flounders:** these flatfish hide against the bottom and have diverse but well developed dorsal surface camouflage to evade predators.
- **Serranidae - Rockcods and Groupers:** many members of this reef dwelling family of predators have exceptionally well developed camouflage.

Corruption in Nature

- Deception and mimicry, where a species evolves the appearance of another to aid its survival, is not as common as camouflage but many excellent examples exist, refer (Preston-Mafham, 2000) and (Randall, 1997).
- Biologists identify two types of mimicry:
- **Batesian mimicry**: “First described by the British naturalist Henry Walter Bates in 1852. He found two unrelated but similarly marked families of Brazilian forest butterflies one of which (model) was poisonous to the birds and the other palatable ones (mimic) survived because of the resemblance to the poisonous ones. They usually mimic the aposematic coloration of the model species. In this kind of mimicry, the mimicking organism has evolved some features of a poisonous organism but is not poisonous itself.” (Dorak, 2004).

Corruption in Nature (2)

- **Mullerian mimicry**: “The German zoologist Fritz Muller proposed an explanation to Bates’s paradox in 1878. Bates had observed a resemblance among several unrelated butterflies all of which were inedible. This paradoxical observation puzzled him. Muller realized that the explanation might lie in the advantage to one inedible species in having a predator learn from another. Once the predator has learned to avoid the particular conspicuous warning coloration with which it had its initial contact, it would then avoid all other similarly patterned species, edible or inedible. Maximum protection is gained by Mullerian mimics when all individuals have the same signal (signal standardization).” (Dorak, 2004).

Corruption in Nature - Examples

- **Lissocarta vespiformis:** this Peruvian leaf hopper bug mimics the appearance of the *Polybia catillifex* wasp, and exists in two known forms.
- **Sphrodolestes and Hiranetis braconoformis assassin bugs:** a number of South American assassin bugs mimic a range of wasp species, the *Hiranetis braconoformis* producing a remarkably good imitation of the *Monogonogastra* braconid wasp.
- **Scaphura katydids:** these relatives of grasshoppers not only appear like wasps in colouration and shape, but also mimic the movements of a wasp when disturbed.
- **Arctiid moths:** these Peruvian daylight moths have transparent wings and black and yellow colouration resembling a wasp.
- **Riptortus bug:** nymphs of this Australian species closely resemble the common green tree ant *Oecophylla smaragdina*, both in colouration and shape.

Corruption in Nature - Examples

- **Paraluteris prionurus:** this small leatherjacket mimics the shape and colour patterns of the poisonous *Canthigaster valentini* pufferfish.
- **Cheilodipterus parazonatus:** this small candinalfish mimics the venomous *sabre-toothed blenny* to deter predators.
- **Antennariidae - Angler Fish:** this family of fish has evolved an elongated first dorsal spine which is used to lure prey close enough to be eaten. While these species use their lure to elicit a predatory behavioural response from their prey, they also employ degradation in the form of camouflage to support the subversion strategy.
- **Aspidontus taeniatus:** this member of the *blenny* family mimics the *cleaner wrasse* in order to approach larger fish and bite parts off the fins, while avoiding predation.

Corruption in Nature – Photuris Fireflies

- North American fireflies of the **Photuris** species employ modulation of their light flashes to attract mates.
- However, females of a number of *Photuris* species are also known to alter their modulations to mimic closely related species, in order to lure males of these species as prey.
- Stous notes that "*Photuris versicolor* is known to prey on eleven species of firefly, and twelve other *Photuris* species prey on at least two, or more, species. On the flip side, one prey species in Florida has 6 predators, therefore there is overlap between *Photuris* species in their flashing [behaviour]".
- These behaviours include luring other species close enough to perform an aerial attack, or hovering in the vicinity of a female which is signalling to ambush arriving males. Refer (Stous, 1997).
- ***The Photuris which lures other species is performing in effect the electronic warfare technique known as meaconing, refer (Schlesinger, 1979). The related variants of these behaviours reflect many established electronic warfare techniques such as manipulation of Identification Friend Foe signals.***

Denial (via Destruction) in Nature

- Denial via destruction is centred upon techniques which disable or impair the basic function of an opponent's sensory apparatus or 'receiver'.
- Noxious or toxic fluid discharges or aerosols which can irritate another specie's olfactory or taste sensor or eyes represent good examples.
- A wide range of species employ this technique, although not as many as employ the preceding strategies.
- Unlike the preceding strategies which might require modest investment in material and energy, maintaining glands with noxious or toxic chemicals does incur a cost, and with a limited reservoir may only be effective for a single encounter with a predator.

Denial (via Destruction) in Nature - Examples

- **Stink Bugs:** a very wide range of stink bug species exist. When disturbed, these typically release a foul smelling aerosol which impairs the ability of a predator to precisely locate the bug by smell.
- **Blattodea - Cockroaches:** a number of cockroach species will spray a noxious fluid when disturbed, again to impair the olfactory sense of the victim.
- **Anisomorpha buprestoides:** this North American walkingstick insect will spray an irritant fluid into the eyes of a predator if threatened.
- **Sepioidea - Cuttlefish:** close relatives of squid, will blind predators by discharging a cloud of ink.

Denial (via Subversion) in Nature

- Subversion is a technique which is used in nature, albeit not as frequently as the other three canonical strategies.
- As it is a more complex strategy to execute, this might explain why it is less common than simpler strategies.
- In practice subversion is often used as the latter phase of a compound strategy, in which very often corruption is employed to gain entry to the victim's system.
- While subversion is the most complex of the four strategies to execute, it is the most devastating to the victim, as it directs the victim's internal resources to a self destructive end. A prerequisite for a subversion attack must be some vulnerability in the basic algorithm which drives the victim system's behaviour.
- The following examples are cited in (Dawkins, 1982).

Denial (via Subversion) in Nature - Examples

- **Cuculus canorus:** The cuckoos subvert the nervous system of the host parent, in order to addict it to the feeding of the cuckoo. Dawkins argues that the subversion performed by the cuckoos might actually be corruption insofar as the cuckoo has elicited a functionally normal albeit misdirected behavioural response from the victim, refer p70 in (Dawkins, 1982). The distinction between some forms of subversion and deceptive behaviour can often be subtle.
- **Bothriomyrmex regicidus and decapitans:** Queens of these ‘cuckoo’ ant species will invade another ant colony, kill the queen and seduce the colony worker ants into rearing the usurper’s brood.
- **Monomorium sanschii:** Queens of this ‘cuckoo’ ant species will will invade another ant colony and emit a chemical which alters the behaviour of the victim ants. These will attack and kill their own queen, adopting the invader as their new queen. If we view the ant colony collectively as part of a survival machine for the queen (a valid, but not uniquely so, perspective) then this is a major example of functional subversion of the target system.

Denial (via Subversion) in Nature - Examples

- **Molothrus ater:** The brown-headed cowbird can elicit preening behaviour from bird species which do not typically preen. Again, this is an example of subversion, as the bird wastes time preening its attacker (while superficially benign, this is an attack, since the victim bird species is wasting time and energy doing the preening), a behaviour that is not a part of its established repertoire.
- **Hymenoepimecis:** The parasitic *Hymenoepimecis* wasp attacks the *Plesiometa Argyra* spider. The victim is stung into temporary paralysis. The *Hymenoepimecis* then lays an egg on the spider's abdomen; the egg hatches into a larva that grows by sucking the spider's internal fluids. The larva induces the spider to build a cocoon web, and then moults, after which it kills and eats the spider. Finally the *Hymenoepimecis* larva spins its pupal cocoon hanging by a line from the cocoon web. This subversion is chemical in nature, refer (Eberhard, 2000).

Key Points

1. Nature is clearly abundant in instances where one or more of the four canonical strategies of Information Conflict have evolved as survival aids.
2. Against the three test criteria we defined to establish that these strategies are indeed evolved features of species, even a cursory browsing of several respectable texts yields a large number of valid examples.
3. The notion that information conflict is a behaviour unique to highly intelligent species, or a feature of social systems alone, is not scientifically supportable.
4. Evolutionary histories of most of the species cited in the examples predate hominids considerably.

Key Points - Continued

5. An open question at this stage, given the immaturity of research in this domain, is the extent to which information conflict impacted the evolution of intelligence in man.
6. Texts on evolutionary psychology, eg (Badcock, 1995) and (Miller, 2000) present many examples which would qualify as information conflict, especially in mating behaviours.

Tutorial

- Review examples in slideshow for *Information Warfare And Evolution* Conference Paper, Proceedings of the 3rd Australian Information Warfare & Security Conference 2002.
- Mimicry vs subversion, mimicry vs camouflage?
- Q&A, discussion.