Detecting the Detector: Readily Testable Examples

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ABSTRACT

This paper adds supplementary information to my previous paper Detecting The Detector[1] and should be read in conjunction with it. It lists additional examples of animals which may be using a detector-detecting sense, permitting straightforward verification experiments in readily accessible environments.

1. Bird detection of cats

Modern domestic cats are major predators of garden birds. It is likely that cats have been significant predators of birds throughout their joint evolutionary history. The modern example might be testable at very modest cost.

As pointed out in[1], a bird which is itself in bright sunlight or moonlight might be able to detect the eye(s) of a predator such as a cat stalking it from the shadows using retroreflection. If the bird has distinctively coloured or iridescent plumage, particularly about the head area, the retroreflected light may be distinguishable from background light by colour. Recent work has found[2] that the eye lens of the cat (like many other animals, although unlike humans) is transparent to UV, so this potentially includes UV colours visible to birds.

To distinguish retroreflection from general background light, it will be very helpful if the bird has a way to rapidly vary the brightness of the retroreflection relative to the background, so that it becomes easily noticeable. The technique is analogous to the old-fashioned blink comparator used by astronomers: by rapidly switching between otherwise identical pictures, any source of light which varies is easily spotted.

Many kinds of birds rapidly vary the size of their pupil in the behaviour known as ‘eye flashing’ or ‘eye pinning’[3]. The circumstances in which they do this include when feeling threatened. When the pupil expands, the distance from the outer edge of the pupil to the inner edge of any bright plumage surrounding the light shrinks: the angle between the edge of the pupil and the edge of the plumage as seen from a point some distance away reduces, so the apparent brightness of narrow-angle retroreflection from such a point, as seen by the bird, will increase relative to the rest of the scene.

A second useful behaviour is possible for a bird that has patches of markedly different colour or brightness immediately adjacent to its eyes. For example great tits exhibit such a pattern, with black plumage above and white plumage below the eye. This pattern is identical in males and females, so unlikely to be linked to sexual signalling. If the tit moves its head so that the black/white boundary transits a boundary between light and shadow, the amount of light reflected from the vicinity of its eye, hence the brightness of any retroreflection it sees, will change relative to the background.

Both these behaviours are readily observable: if they occur in response to a threat, for example a sound which could indicate the approach of a cat, this will be evidence for the eye retroreflection-detection hypothesis. The evidence will be confirmed if unmasking a pair of retroreflectors simulating a cat's eyes, placed in deep shadow so they are not visible by other light, triggers a startle response.

It should be noted that mutual eye flashing/pinning could also provide a means for two birds to communicate, a stealthy communication that would be difficult to detect by a third party lacking a retroreflection-detecting sense.

2. Mantis shrimp – detecting animals in burrows

Mantis shrimp were identified in[1] as animals which may very plausibly detect cephalopod or vertebrate eyes by retroreflection of circularly polarized light; in the latter case, even direction of gaze may be inferable, due to partial linear polarization of the interrogating light at the point where it strikes the retina by nerves running toward the central blind spot. This effect has been observed in research using circularly polarized light to track human gaze direction[4]. Examples of vertebrate predators which hunt underwater include cetaceans and pinnipeds at depths down to a mile or so, and diving and wading birds at shallower depths.

Detection of cuttlefish, which are known to predate mantis shrimp and tend to lurk in seabed burrows where they are very difficult to detect by other means, is a particularly promising case. A recent experiment has found that given a choice of burrows, mantis shrimp do prefer to head for one from which no circularly polarized light is emitted[5]. This has been interpreted by the authors as avoidance of burrows which are already occupied by another shrimp. However it could also indicate avoidance of burrows which contain cuttlefish, as revealed by their eye retroreflection. One way to distinguish the two possibilities would be to see whether the shrimp takes account of the polarity (clockwise or counterclockwise) of the light, and whether this matches the polarity of the light reflected from its own carapace, allowing for polarity inversion on reflection. Also if the shrimp is detecting possible retroreflection, it should be able to make the intensity and/or colour of the retroreflected light vary predictably by altering its own orientation and/or the deployment of its limbs. Observations should be made to determine whether it does exhibit such behaviour when selecting or investigating a burrow.

3. Scarab beetles and circular polarization

At least some of the extensive scarab beetle family reflect light circularly polarized from parts of their carapaces, and have the ability to selectively detect circularly polarized light.[6] This could alert them to potential predators looking in their direction, including: spiders, birds, rodents, lizards, frogs/toads and even fish which can take prey from above water such as anglerfish. This is testable with retroreflectors simulating such predators.

4. Detection of humans by predators

Human babies instinctively close or conceal their eyes when playing games involving hiding. A likely reason for this is the hard-wired ability of humans and other animals to detect a face-like shape with eyes, nose and mouth, which is reduced when the eyes are concealed. However it is also possible that at some point in our evolutionary history, humans were significantly predated by animals which used our ‘redeye’ retroreflection, as visible in old-fashioned flash photographs, to detect us. An example might be birds hunting us when we were in shade, for example in a forest, but the bird in bright sunlight or moonlight and able to use light scattered from its body to detect us. If infants have a particular tendency to close or hide their eyes in hide-and-seek games designed to resemble this scenario, this could provide at least weak evidence for this hypothesis.

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