EEB 4260: Sensory Biology

Class Business

Reading for this lecture

Required. Gill: Chapter 7
Optional. Procter & Lynch: Pages 241-261

1. Introduction

A) HOW DO BIRDS PERCEIVE THE WORLD?

Birds share a similar set of senses to humans and other mammals. Like humans, vision and hearing are probably most important for most bird species. But, the senses of birds as a class have developed in many ways that make them quite different from many other vertebrate groups. Consequently, birds perceive the world in a way that is probably very different from they way that we do.

B) HOW DOES THEIR PERCEPTION DIFFER FROM OTHER VERTEBRATES?

- High visual acuity
- UV vision; polarized light
- Echolocation/sonar
- Infrasound
- Magnetic field detection
- Atmospheric pressure detection
- Pressure transduction

2. Vision

A) EYE STRUCTURE

i) Basic structure is similar to mammals. Key parts that you will need to know the location and function of include: **cornea**, **lens**, **pupil**, **retina**, **cones**, **rods**, **fovea**, **pecten**, and **optic nerve**.

ii) The pecten is a unique structure found only in birds (although a similar structure exists in modern reptiles). Its function is not known and there are many ideas about what it might be for, but one leading hypothesis is that it enables birds to get nutrition and oxygen into their eyes.

iii) Bird eyes are relatively very big compared to their head size. For example, some birds of prey have eyes that are larger than those of humans. Eye shape varies among birds, with some species (e.g., eagles) having very elongate eyes. This is thought to help increase their visual acuity.

iv) Most birds have their eyes on the side of their head (there are exceptions, e.g., owls). This gives them a wide field of view but means that they do not have good binocular vision like you do (**binocular vision** is what gives you good depth perception). Birds can compensate for this though by bobbing their heads constantly. This means that they can look at something from two different angles with the same eye but in quick succession – rather than looking at something with two eyes simultaneously. Some birds have their eyes set so far back that they can see behind themselves.

B) IMAGE QUALITY

i) Acuity (ability to see detail at a distance). 2-3 times better than humans. Much greater density of light receptors (cones) and more nerve fibers to take information to the brain (via the optic nerve). Birds also have a wider field of sharp vision than do humans. Some birds (many aerial hunters) that need especially good vision have a second fovea (the **temporal fovea**) in each eye – this is thought to improve binocular vision.

ii) Focusing. Birds can change the curvature of both their cornea and lens to focus (only the lens is used by mammals). Birds can focus very quickly – much more so than humans.

iii) Color. System for color detection is completely different from mammals. Cones contain oil droplets - the color of which influences the way in which color is seen. This system is thought to be much better than that of humans. Birds also can see into the UV portion of the spectrum, so they see colors that we cannot. This means that the way they appear to each other is different from the way they look to us (which can be important in mate selection) and that the way they perceive the environment is different (e.g., Eurasian Kestrels are able to see the urine trails left by mice, which absorb UV light).

3. Hearing

A) EAR STRUCTURE

i) Birds have simpler ears than mammals. There is no external pinnae like those on the sides of your head. Parts that you should know the location and function of include: **auricular feathers**, **columella** (= **stapes**), **tympanum**, **cochlea**, **semicircular canals**,

ii) Although bird ears are small compared to those of mammals, they have very high densities of sensory cells, suggesting that their hearing is still very good.

B) HEARING ABILITY

i) The range of frequencies that any particular bird can hear is probably less than that of a human, but this range varies among species so birds as a group can hear a wide range of sounds.

ii) Some birds have unusual abilities for particular types of hearing. For example, some species (e.g., pigeons) can hear ultrasound (very low frequencies); woodpeckers can hear insect larvae moving around under the bark of trees; South American Oilbirds and Asian swiftlets use echolocation to find their way around in the dark.

iii) The best hearing is found among nocturnal birds; owls have been especially well studied. Barn Owls have very good hearing and can catch mice in complete darkness. Some species of owls have asymmetrical ears (one is higher than the other); in a few cases this asymmetry extends to the skull shape. This asymmetry allows owls to triangulate on sounds much more accurately, in particular by allowing them to locate sounds along a vertical axis.

4. Smell and taste

A) BIRDS CAN SMELL (CONTRARY TO PAST IDEAS)

i) Most birds have **olfactory bulbs** that are relatively small compared to their brain size and it was long assumed that they could not smell very well. It now seems, however, that most birds have a reasonably good sense of smell.

ii) The sense of smell is particularly well developed in certain groups of birds, and ability to detect odors seems to be correlated with the relative size of the olfactory bulb. Examples include: vultures (which use smell to find rotting carcasses), petrels, including albatross and shearwaters (these seabirds use smell to find food out on the featureless ocean), nocturnal species (e.g., kiwis, which feed at night and have nostrils right at their bill tips, and storm-petrels, which visit their nests at night and seem to use smell to locate their burrows within dense breeding colonies).

B) BUT TASTE IS LESS CERTAIN

i) Birds have taste buds, but very few compared to humans.

ii) Taste in birds definitely differs from that in mammals. For example, birds have no trouble eating very hot chili peppers that mammals avoid. In fact, chili plants may have evolved capsaicins (the chemicals that burn your tongue) in order to deter mammalian seed predators, while attracting birds that eat the fruits while dispersing the seeds unharmed.

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5. Other senses

- Touch. In some cases birds have a well developed sense of touch. Certain feathers (filoplumes, bristles, see Lecture 3) have mechanoreceptors (**Herbst's corpuscles**) at their base; these presumably

help birds to manipulate feather position. Some birds that feed by probing in the mud (e.g., some shorebirds) have extremely sensitive bill tips that allow them to determine the presence of prey items.

- Pressure transduction. At least one shorebird species (Red Knot) has even been shown to be able to sense variations in hydrostatic pressure that occur around objects [such as prey (shellfish) buried in the mud]. By driving their bills in and out of the mud, these birds can detect the pressure changes that occur when there is a hard object at the bottom of the hole. They can also tell from the way the pressure changes, where the object is relative to the bottom of the hole.
- Barometric pressure. Birds seem to be able to detect approaching storms, presumably because they can detect the change in barometric pressure. Homing pigeons have been studied in detail and can detect very small pressure changes.
- Balance. The semicircular canals in the ear give birds a very good sense of balance and position in the air.
- Magnetic field detection. At least some birds are able to detect the magnetic fields that vary from place to place depending on geology. This information is used during navigation. Again, this phenomenon is best studied in homing pigeons.