Cover illustration

Double crossed

Most owls have excellent nocturnal vision but are helpless in total, complete darkness. Not so the remarkable barn owl (*Tyto alba*). Differing from the more traditional owls, barn owls are members of the family *Tytonidae*, a small family of birds with distinctive ear bones. These birds are keen hunters capable of acoustic location in total darkness without the help of any photons!

A nocturnal owl, *Tyto alba* is one of the few birds that are virtually pandemic in its distribution, inhabiting all continents except Antarctica. With a distinctive appearance known to most of us, this owl has a heart-shaped facial disc that funnels sounds to its paired, but asymmetrically placed, ear holes. These ear holes allow for very accurate localisation of sound so that the barn owl can actually strike its prey in total darkness. Boasting several novel anatomical and neurological design features, the asymmetric ears and auditory processing of this owl are capable of detecting very slight interaural time differences. That ability enables a most enviable auditory sensory mechanism that provides accurate azimuth and elevation localisation, as well as directional motion detection to an accuracy of approximately 2–3°!

Nevertheless, even with its extraordinary hearing, this owl has the typical excellence in visual acuity found in most owls. The bird has predominantly rod retina restricting it to a nocturnal lifestyle. It has a rather limited range of accommodation probably with a maximum of 10 dioptres, although accommodation may be used as a distance clue for this bird. It has large eyes with a very large anterior chamber helping to create a long anterior focal length. This 400 g animal has a cornea that is 12 mm in diameter with an axial length of 18 mm. This allows for the image to be spread over a wider area on the retina and hence increased image size. As can be seen in the figure on this page, the eyes are asymmetrical and tubular in shape with cartilaginous/bony supports just anterior to the equator. The extraocular muscles have atrophied evolutionarily, and are rudimentary. This means that the owl cannot move its eyes, and must rely upon its thin, flexible spinal column and strong neck muscles to allow for rapid and dramatic head movements of as much as 270° and the ability to turn its head almost upside down.

Barn owl eye. Note the asymmetrical globe with a large equatorial diameter.

Most birds have a completely crossed chiasm and each eye should be completely, and only, represented in the contralateral visual cortex, but such is not the case with barn owls. Pettigrew documented that they have excellent stereopsis (Pettigrew JD *et al, Science* 1976;**193**:675), which could be guessed from the frontally placed eyes and predatorial lifestyle. He later documented that there is a second supraoptic chiasm that allows for approximately 50% of the ipsilateral fibres to cross the brain a second time allowing for input of each eye to each side of the brain, providing stereopsis equivalent to humans. This second crossing represents neurological convergent evolution suggesting that stereopsis is essential for predators and can evolve in different ways.

But vision has a uniquely important role for this creature. The owl may rely upon its excellent auditory system, but the auditory spatial map is trained visually. Located in the inferior colliculus, the auditory maps have sharply tuned neurons (tuned to frequency and spatial location). These neurons project to the optic tectum (analogous to the superior colliculus in mammals) resulting in a spatial map receiving input from the eyes and ears. Hence, the auditory space aligns with, and is taught by, the visual system. This animal can "see" with its ears because these summed inputs then project into the "Wulst" (visual forebrain considered analogous to the visual cortex of mammals), although perceptually this would be impossible for us to understand completely.

The visual system of barn owls has at least one more clever adaptation. Our brain may recognise objects by form alone, requiring contour recognition. In a natural environment, however, contours may be incomplete because of other objects, shadows, or camouflage. Investigators have shown that barn owls can indeed make assumptions about incomplete contours, entitled subjective contours, to fill in the gaps. Furthermore, direct neuronal recordings have documented this "coding" of subjective contours and the process of high order perceptual interpretation (Nieder A *et al*, *Nature Neuroscience* 1999;**2**:660–3). Simply put, the target rodents cannot hide in scattered weeds and foliage as this will not successfully break up the "search image" of the owls. This added layer of sophisticated visual processing permits this bird to be a highly effective nocturnal hunter.

Barn owls occupy various habitats, although they are usually a grassland/marshland species. Most owls are helpful to human agriculture, but this one is exceptionally so, consuming approximately 1½ times its weight in rodents each night during the nesting season and somewhat less during other parts of the year. Since the bird is not particularly fast it must rely upon stealth to catch its prey and, indeed, because of special adaptations to its feathers along its exposed flight surfaces, it is silent as it approaches dinner.

These awesome visual and auditory predators represent an evolutionary triumph of vertebrate sensory evolution.

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Images by the author
Thanks to William DeBello for the specimens to study and his comments on the essay.

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Br J Ophthalmol 2003 87: 1442
doi: 10.1136/bjo.87.12.1442