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Underwater and Aerial Visual Acuity in the Asian "Clawless" Otter *(Amblonyx cineria cineria)*

Gentry and Peterson[1] have compared data obtained from a sea otter (*Enhydra lutris*) on an underwater size discrimination task with data obtained by Schusterman *et al.*[2] using two sea lions (*Zalophus californianus*). Although Gentry and Peterson did not test the sea otter's vision in air, they concluded that its performance was inferior to that of the sea lion because the "pinniped eye" is emmetropic underwater with adaptations for aerial vision and that the "otter eye" (*Lutra*) was emmetropic in air with adaptations for underwater vision[3]. Such an interpretation of the difference between otters and sea lions emphasizes different dioptric mechanisms and ignores neural structure and organization at the retinal level, as well as at the level of the cortical projection areas.

Without determining that it can see better in air than underwater, the finding that the underwater visual acuity of the sea otter is poorer than that of the sea lion may have little connexion with their accommodative processes which are totally different[3]. Instead, the superior underwater visual acuity of the sea lion can be attributed to the superior resolving power of its retina. Although there has been no comparison of the detailed retinal structure and organization in otters and sea lions, the ratio of

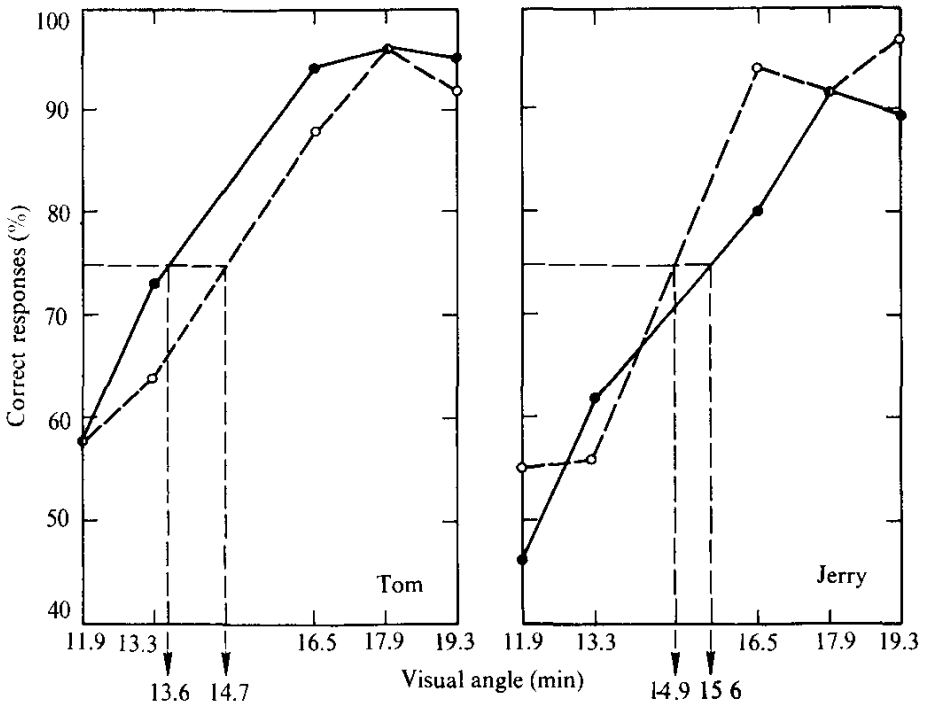

Fig. 1 The underwater (●) and aerial (○) visual acuity of otters (Tom and Jerry).

receptor to ganglion cells in sea lion retinas[4] is consistent with the finding that sea lions can resolve grating spacings subtending a visual angle of 5.5 minutes of arc both in air and underwater[5]. Tests of the behaviour of the ferret (*Mustela f. renata* and *Mustela corninea*), a close relative of the otter, indicate that maximum visual acuity of these mustelids[6] in air is about one third that of the sea lion. Furthermore, the type of stimulus configurations initially used by Schusterman *et al.*[2] and subsequently by Gentry and Peterson[1] were relatively inappropriate for measuring visual acuity uncontaminated by intensity

discrimination[5]. To resolve some aspects of these issues concerning the suitability of the visual systems of different aquatic mammals we tested the aerial and underwater visual acuity of two mature male Asian "clawless" otters (*Amblonyx cineria cineria*). These mustelids are widely distributed throughout south-east Asia. Their diet includes fish, frogs, crabs and birds, and they are reported to be used by the Malays for fishing[7].

Both animals were trained and tested outdoors in a white plywood tank measuring $2.3 \times 1.2 \times 1.6$ m. Detailed descriptions of the equipment and general procedures which were used are reported elsewhere[8,9]. Acuity targets were produced from 12.7^2 cm photos of Ronchi rulings with black and white stripes of equal width. The standard grating consisted of 300 lines per inch. The variable gratings consisted of lines varying in width from 12.7 mm to 4.8 mm. Targets were presented simultaneously by the experimenter lowering a target board from behind an opaque screen. The otters were maintained at a fixed distance of either 1.9 or 1.3 m from the targets with an opaque divider which projected down to the tank floor and outward from the opaque screen. The task was to approach the target with the variable grating in order to obtain a piece of chicken neck weighing 0.6 g. Once an animal left the start position after viewing the targets it was not allowed to retrace. If, after leaving the start position, an otter swam or ran to the side of the divider with the standard target it had to push that target; otherwise, the targets were withdrawn and the response was counted as an "error". The minimum distance between the gratings and the animal was taken as 1.9 or 1.3 m. Training and determination of a range of acuity targets were accomplished in a manner similar to that described for the testing of pinniped visual acuity[5,8,9].

Threshold estimates were obtained by the method of constants first used at a distance of 1.9 m with three variable targets subtending visual angles of 11.9′, 16.5′ and 19.3′ for 20 days and then at a distance of 1.3 m with variable targets subtending visual angles of 13.3′ and 16.5′ for 12 days. Each variable target was paired randomly with the standard for ten consecutive trials. Pairings were repeated twice for a total of sixty trials per day. Testing in air and underwater alternated daily.

Fig. 1 shows both aerial and underwater psychophysical functions for each otter. Thresholds may be found by noting the visual angles associated with 75% correct responses. These functions clearly show that the aerial and underwater visual acuity of *Amblonyx* is about the same. Threshold estimates measured in minutes of visual angle over the 16 test days were 13.6 and 15.6 for aerial acuity and 14.7 and 14.9 for underwater acuity. These figures are similar to those obtained on the aerial visual acuity of other mustelids[6].

These results suggest that it is not the totally different dioptic mechanisms (as has previously been suggested[1]) which account for the inferior underwater visual acuity of otters compared with sea lions and seals, but rather the poorer resolving power of the otter retina in combination with other neural elements including the cortical projection areas. Apparently, the dioptric mechanism of otters is such that it allows the eye to function normally in air without any special accommodative effort and is also capable of producing enough accommodation underwater[3] so as not to limit the visual acuity of the submerged otter.

Because it is supposed that the protopinnipeds were lacustrine and that they fed along the shores of streams, lakes or the sea, as do some modern otters, and because it has been suggested that the true seals may have descended from an otter-like ancestor[10], it is of considerable interest in terms of the evolutionary history of sensory systems of modern pinnipeds to compare the visual acuity of some otters with that of seals and sea lions. In spite of the limited data which are currently available it seems that the visual acuity of some pinnipeds[4,5,8,9] resembles more closely that of cats[4] than it does otters.

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