EVIDENCE FOR CONE FUNCTION IN THE DOLPHIN RETINA - A PRELIMINARY REPORT

A. van Esch and J. de Wolf, Lab. for Comparative Physiology, State University, Utrecht, Netherlands

Summary

In a series of behavioural experiments it was found that a bottlenosed dolphin *(Tursiops truncatus)* distinguishes separate light flashes up to a frequency of at least 28 per second. This result indicates that the animal's retina contains elements which, with respect to temporal resolution capability, perform cone function.

Introduction

As reviewed by DRAL (1977), the retina of Cetacea contains two types of visual cells, the great majority being typical rods, while a small percentage shows some morphological cone characteristics and can be suspected to be cones. In view of their scarcity the question has been raised whether these cells, if they are cones at all, can appreciably contribute to the visual process. The question is of importance because, since cones and rods function differently (mainly complimentary), even a small number of functional cones could usefully expand the animal's visual capacities. The above question, usable cone function or not, can only be answered by behavioural experiments, aimed at the differences in function of rods and cones. Most suitable for an experimental approach is the difference in critical flicker frequency (CFF). With CFF is meant the minimum frequency at which a train of lightpulses is perceived as a continuous light. In rods CFF usually is found to be not higher than some 18—20 flashers per second (GRUBER, 1977), in cones this value is considerably higher. Many factors have an influence on CFF (GRAHAM, 1965), but these can be neglected as long as they are kept constant through the series of experiments. We worked with varying light intensities of the stimulus, one of the main influences on CFF. However, in this preliminary report we prefer to present the results without taking its effects into account.

Methods

The stimulus, either a continuous or a flickering light, was projected on a ground glass screen under water. By means of a bar the animal, a female bottlenose dolphin *(Tursiops truncatus)*, was kept at a constant distance of 1 m before the screen, in such a position that she looked at the screen binocularly. She was trained to press a left hand or a right hand button, according to whether a continuous or a flickering light was presented. During the sessions the sequence of continuous and flickering light, as well as the frequency of the latter, was randomly varied.

Results and discussion

Table I presents the numbers of right and wrong choises at those flicker frequencies of which we had sufficient observations (more than 50) to apply the X^2-test.

Table I

frequency flashes/sec	wrong choises	right choises	X^2	p
20	10	50	26.6	< 0.005
22	11	57	31.1	< 0.005
24	18	51	14.8	< 0.005
28	23	76	27.3	< 0.005
36	38	30	0.94	0.1 < p<0.9
40	39	15	10.7	< 0.005

The X^2-test was carried out on hypothesis that continuous light was not distinguished from flickering light. It appears that this expectation is only fulfilled at a frequency of 36 flashes/sec. The lower frequencies were significantly below CFF, whereas the results at 40 flashes/sec show that fusion of the light pulses must have taken place.
Though this study does not provide an exact value for CFF, it shows that it goes far above that which can be expected from rods. The conclusion must be that the dolphin retina contains functioning cones.

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References

DRAL, A.D.G., 1977. On the retinal anatomy of Cetacea. In: R.J. Harrison (ed.), Functional anatomy of marine mammals, III. Academic Press, London and New York.
GRAHAM, C.H., 1965. Vision and visual perception. Wiley and Sons, New York, London, Sydney.
GRUBER, S.H., 1977. The vision of sharks: a perspective. Naval Research Reviews 30(2): 1-21.