Acoustic localization in an ostariophysian fish

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Summary. Under approximate free field conditions acoustic localization could be demonstrated in an ostariophysian fish, the ide (Leuciscus idus). The efficient vibration links of both sacculi with the unpaired swimbladder (via the Weberian ossicles) do apparently not preclude directional hearing in this important group of freshwater fish.

It has been proved that many sharks[2–6] and several teleosts[7–10] are able to localize a sound source, even if it is at a considerable acoustic distance[11]. At least in cod (Gadus morhua), 2 intact labyrinths are required for directional hearing, as follows from elimination experiments[10,12]. Recordings of the saccular microphonics in perch have shown that the left and right saccular otolith constitute a bilateral pair of acceleration detectors with different axes of optimal sensitivity[13]. When the body of the fish is carried along with the particle displacements in the incident sound wave, this vector-detection system might convey the direction of these particle displacements in a process that is termed 'vectorial weighing'. In the past many authors have argued that the presence of a swimbladder would exclude such a differential stimulation of the labyrinths because each of the labyrinths would be identically stimulated by the near-field from the pulsating swimbladder. If sufficiently strong, such a coupling of the ears with the swimbladder would result effectively in a single pressure receiver that is not directionally responsive because the acoustic pressure itself does not contain information on the bearing of the sound source. However, electrophysiological experiments on intact cod by one of us[14] have shown that, at least in this species, part of the ear responds directionally to a kinetic sound variable, even when at the same time subjected to pressure-induced radiation of the swimbladder.

Cod lacks a special link between swimbladder and the labyrinths. In ostariophysi, however, the Weberian ossicles transfer the swimbladder vibrations to the tiny saccular otoliths, so that one expects a much stronger coupling between the labyrinths and the swimbladder. The purpose of the present experiments is to show that this coupling does not preclude directional hearing in the ostariophysi, the bulk of the fresh-water fish. Directional hearing was studied for 2 special bearings of the sound projectors only: 'in front of' or 'behind' the fish, respectively.

We have chosen for a food conditioning in the orfe (Leuciscus idus Linné: Cyprinidae), the golden variety of the ide. The fish was kept in a netting cage 3.5 m below the surface of a large 26 m deep recreation lake near Maarsseveen (Neth.). The cage (⌀ 1 m) had 2 diametrically opposed feeding places, A and B; the line AB was parallel to and straight under the long side of a rectangular raft of 4×6 m. Vertical netting screens around the centre of the cage in the configuration ⊂⊃ served to guide the fish towards the centre of the cage with the body parallel to AB. Sound was only presented when the fish was in the correct position parallel to AB. The fish was trained to swim towards the sound projector that emitted the stimulus: it was rewarded if it moved towards the feeding place closest to the sound source. Both sound projectors were at a radial distance r of 1.75 m. For the observer on the raft, A was the right feeding place, corresponding to stimulations from direction I (arbitrary designation), etc. Pure tones of 75 Hz were switched on and off by means of photoresistors. The acoustic pressure was 5.0 μbar. Stimulations impinging on the head and on the tail were divided into different categories. Furthermore stimuli were divided according to the identity of the sound projector used (1 or 2), and to propagation direction of the sounds: I or II. After every 10 trials the positions of the sound projectors were interchanged. The fish responded to the stimuli by darting towards the feeding place either directly (ahead) or after having turned through 180° (turn). A negative factor in scoring responses to tail stimulations was that the fish frequently swam to the correct feeding place, not by turning around inside the netting screens, but by taking the route immediately outside the netting screens: such a response fell into the category ahead. On arrival at the feeding place, the fish would wait for food if it was put to a test: this, however, was not required as response criterion. The data[15] are arranged in 4 2×2 tables according to the following scheme:

		response		
		ahead	turn	
stimulus arriving on	head	x	m − x	m
	tail	y	n − y	n
		C	N − C	N

I 1	12	1	13	I 2	8	2	10
	3	13	16		6	4	10
	15	14	29		14	6	20
II 1	9	1	10	II 2	13	2	15
	4	6	10		8	9	17
	13	7	20		21	11	32

The unknown probability of a response to 'head stimulation', being classified in the first column of a 2×2 table, is denoted by p; p′ denotes the same probability for tail stimulations. The nullhypothesis H_0 reads: the probability of swimming ahead on stimulation is independent of the location of a sound projector, hence $p = p'$. The alternative hypothesis H_1 which indicates discrimination of the directions I and II reads: $p > p'$. We can combine the effects detected in each of the 4 2×2 tables by testing simultaneously $H_0 : p_i \leqq p_i'$ against $H_1 : p_i > p_i'$, where $i = 1, 2, 3, 4$ denotes an index for the different 2×2 tables. The combination test rejects H_0 for large values of the statistic $T = \sum_{i=1}^{4} x_i$, given the marginal totals of the various 2×2 tables[16]. Under H_0 the conditional distribution of T is approximately normal with mean[17] $\mu = 30.07$ and variance[17] $\sigma^2 = 6.013$ hence

$$\text{Prob}\ \{ T \geqq 42 \mid H_0 \text{ is true} \} < 10^{-4}.$$

We reject H_0 and conclude that the fish achieved a higher score of correct choices than could be expected if the fish responded non-directionally to this type of sound. This formulation is a consequence[18] of rejecting H_0. Certainly this fish favoured swimming forward through the exists in the netting screens, but the described combination test enables us to reject the hypothesis that the fish simply swims forward on sound. Directional hearing has been shown at least for the coarse discrimination of bearings 180° apart. This ability alone has (already) biological meaning. It is quite probable that the orfe possesses a much better angular resolution. We did not test this directly owing to the risk of another act of willful hindering[15] in the field.

Von Frisch and Dijkgraaf[19] and Reinhardt[20] have been unable to show acoustic localization in Ostariophysi, except when the fish were within a dm range from the sources. We tentatively attribute their negative results to inadequate qualities of the applied sound fields (too few low-frequency components?). Since in our experiments there was no correlation between the polarity of the acoustic pressure at the onset of the sounds and the location of the sources, we conclude that the discrimination cannot be based on detection of the initial polarity of the acoustic pressure: a sensory ability demonstrated by Piddington[21] for goldfish. We think that in our experiment a phase analysis between acoustic pressure and particle displacements as shown for cod[22] explains the discrimination of oppositely travelling waves.

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[17] $\mu = \sum_{i=1}^{4} m_i C_i / N_i \qquad \sigma^2 = \sum_{i=1}^{4} m_i n_i C_i (N_i - C_i) / \{N_i^2 (N_i - 1)\}$

[18] Let the value of p_i and p'_i under H_o be π_i. If we accept H_1 then we have $p_i > \pi_i > p'_i$. The expected number of correct choices is $mp_i + n(1-p'_i) > m\pi_i + n(1-\pi_i)$.

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High density lipoproteins in ischaemic heart disease[1]

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Summary. High density lipoprotein cholesterol concentrations were significantly lower in ischaemic heart disease patients than in healthy subjects when age and sex-matched. This difference was, however, not observed in the older age group (> 60 years).

Ischaemic heart disease due to coronary atherosclerosis (obstruction of the coronary artery as a result of lipid deposition in the arterial wall) is a major world problem at the present time[3,4]. There are many risk factors for ischaemic heart disease. Hypercholesterolaemia[5,6] and hypertriglyceridaemia[7] are known to be associated with ischaemic heart disease. The role of lipoproteins in the aetiology of ischaemic heart disease has, however, not been fully explored. Recently it has been indicated that high density lipoprotein is an antiatherogenic agent[8]. The mode of action of high density lipoprotein as an antiatherogenic agent is not, however, completely understood. Suggestions have, at any rate, been made as to the means by which high density lipoprotein could act as an antiatherogenic agent. One of these[9] believes that high density lipoprotein has the ability to solubilize exogenous cholesterol in addition to its own cholesterol content, thus preventing influx of cholesterol into the arterial wall. The localization of ApoA-1 in atherosclerotic lesions[10] may also indicate that high density lipoprotein has the ability to transport lipids from the arterial wall to the plasma.

Another mode of action of high density lipoprotein is believed[11] to be due to its ability to inhibit uptake and degradation of low density lipoprotein, and depress net increment in cell sterol content. Low density lipoprotein is the main carrier of cholesterol and inhibition of its degradation may prevent accumulation of cholesterol in the arterial wall.

Material and methods. Healthy subjects. These were made up of 99 white British-born men and women between the ages of 20 and 69 years living in the London area. Subjects were selected on the basis of absence of clinical or ECG

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