Studies on Conditioned Responses in Fishes. Part V. On the Controlling Influence of Normal Behaviour Traits upon Capacity to Form Experimental Conditioned Motor Responses Under Certain Conditions.*

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In Part III of these studies (**3**) it was shown that *Blennius pholis* readily forms conditioned motor responses towards lights of various wave-lengths when these are associated with a succeeding electric shock. Many experiments were required to establish an adequate knowledge of the capacity of this species of fish to discriminate between these various wave-lengths. It was possible, however, that all species of fish would not be equally suitable for this type of experiment. In view of this some preliminary experiments were made with other species. A condensed account of some of these results is given in this paper chiefly because they reveal a striking difference between fishes belonging to the Pleuronectidæ and those belonging to the other families investigated. Fishes belonging to the Pleuronectidæ were found to be incapable of forming conditioned motor responses to a circle of light when this was associated with a succeeding electric shock. The other fishes investigated readily formed such conditioned responses.

The experiments were carried out at night in the special sound-insulated building described in Part IV (**4**). The procedure was that of the earlier experiments described in Part III (**3**). Only those fishes were used which were in a thoroughly healthy condition and behaved in captivity in the manner typical of their kind. They were normally kept in specially reserved tanks in the aquarium under personal supervision. Each day of trials the fish was transferred to the experimental apparatus (described in Parts I and III, **1**, **3**) approximately 30 minutes before the first conditioning test ; it was then given an average of 8 conditioning tests ; after a further period of rest of approximately 30 minutes it was returned to the tank where it normally lived.

* Part IV has appeared in the Report of the Dove Marine Laboratory, Cullercoats, year ending 1st July, 1934. It is devoted solely to the description of a sound-insulated building erected for the purpose of carrying out these researches under more constant conditions and free from extraneous influences.

The conditioning test was the same for all. A circle of light 1·5 inches in diameter, at a distance of 5 inches from the fish was formed by the light from a 100-watt lamp transmitted through a Wratten light filter No. 32 (magenta). Full particulars of the arrangement and the method of noting the response of the fish are given in the earlier paper (Part III, p. 348 *et seq.*). An electric shock was given to the fish at the same instant as the making of the same circuit produced the circle of light. By giving the electric shock simultaneously with the light in this way it follows that, even if the fish were becoming " conditioned " any conditioned motor reaction would be masked by the supervening shock reaction. Hence for the purpose of ascertaining the progress of " conditioning " the light was shown periodically without the associated shock. This may be seen in the log of the experiment on *Spinachia vulgaris* in Table I.

This simultaneous " conditioning " was attempted for a special reason which will be discussed fully at a later date, but is here briefly outlined. There are, as is well known, two essentially opposed groups of theories of animal behaviour : (A) Mechanistic, reflex, tropistic, etc. (B) Vitalistic, hormic, conative or " goal-seeking," etc. Leading exponents of (B) say unequivocally that we should *accept as granted* an inherent conative or goal-seeking tendency in animal behaviour (**5**). Of various avenues of approach, the study of animal learning has provided a large part of the material from which the conception of conative activity is derived. An integral part of this conception is the expression of *laws* of learning in terms of an animal's *needs* and the *satisfaction* of those needs. Critically and competently used such a concept and such expressions may be valuable as an aid in the description or the comprehending of facts, or sequences of events in animal reaction, whose real nature is for the time elusive. Objective enquiry can hardly rest content with this facile type of descriptive interpretation. If, for example, it could be shown in a sufficient number of representative animals that truly simultaneous conditioned reflexes (in the strict sense) or responses (in the broader sense) could be established, and that they followed the same course as general learning activity where conation is accepted by school B it would be possible to say that the two processes had a common basis and that it was highly probable that the latter (being the more complex) could be derived directly from the former. This would mean that conation had a basis which one might fairly expect to elucidate analytically, for it is clear that a strictly simultaneous conditioned reflex cannot have a conative basis.

The present experiments make no attempt to offer conclusive evidence upon this point. They do show, however, that in those fishes where conditioning has been established it *is* possible to use simultaneous presentation of the unconditioned with the conditioning stimulus, but that the conditioned response itself, as noted by the registration of total

TABLE I.

Record of an Experiment on *Spinachia vulgaris* (L) showing the Formation of a Conditioned Motor Response towards the Visual Stimulus of a Circle of Magenta Light, using an Electric Shock as the Unconditioned Stimulus. Length of Specimen 13·5 cm.

Date, times, etc.	Time of Expt.	Serial No. of Expt.	Resultant movement to A. Signalling Stimulus.	B. Electric Shock.
Feb. 23 [put in app. 17 00; removed at 18 50]*	17 50, 55; 18 00, 05, 10, 20	1 to 6	—	Strong.
	18 25	7	None	No S.†
	18 30	8	—	Strong.
Feb. 24 [put in app. 17 10; removed at 19 10]	18 15, 20, 25, 30, 35, 40	9 to 14	—	,,
	18 43	15	None	No S.
	18 45	16	—	Strong.
Feb. 26 [put in app. 17 30; removed at 18 25]	17 50	17	—	,,
	17 55	18	V. slight at 4 sec.	No S.
	18 00, 05, 10	19 to 21	—	Strong.
Feb. 27 [put in app. 19 00; removed at 20 20]	19 30, 35	22, 23	—	,,
	19 40	24	Moderate at 3 sec.	No S.
	19 45, 50	25, 26	—	Strong.
	19 55	27	None	No S.
	20 00	28	—	Strong.
March 1 [put in app. 18 25; removed at 19 35]	18 45	29	—	,,
	18 50	30	Vigorous at 1 sec.	No S.
	18 55	31	—	Strong.
	18 58	32	Distinct at 2 sec.	No S.
	19 00	33	—	Strong.
	19 05	34	Vigorous at 0·4 sec.	No S.
	19 10	35	—	Strong.
	19 12	36	Vigorous at 1 sec.	No S.
	19 15	37	—	Strong.
March 3 [put in app. 21 02; removed at 22 10]	21 30, 35	38, 39	—	,,
	21 40	40	Distinct at 2·4 sec.	No S.
	21 45	41	—	Strong.
	21 47	42	Strong at 1·2 sec.	No S.
	21 50	43	Strong at 0·8 sec.	,,
	21 55	44	—	Strong.
March 5 [put in app. 18 15; removed at 19 20]	18 30	45	—	,,
	18 35	46	Strong at 2·8 sec.	No S.
	18 40	47	—	Strong.
	18 45	48	Strong at 3·0 sec.	No S.
	18 50	49	Distinct at 2·4 sec.	,,
	18 55	50	—	Strong.
	18 58	51	Strong at 1·2 sec.	No S.
	19 02	52	,, 0·4 sec.	,,
	19 04	53	,, 0·2 sec.	,,
	19 06	54	,, 0·2 sec.	,,
March 6 [put in app. 20 10; removed at 21 15]	20 30	55	—	Strong.
	20 35	56	,, 0·6 sec.	No S.
	20 40	57	,, 0·8 sec.	,,
	20 45	58	—	Strong.
	20 50, 55	59, 60	,, 0·2 sec.	No S.
	21 00	61	—	Strong.
March 7 [put in app. 21 10; removed at 22 30]	21 40	62	—	,,
	21 45	63	,, 0·2 sec.	No S.
	21 50	64	—	Strong.
	21 55	65	,, 0·2 sec.	No S.
	22 00	66	,, 1·4 sec.	,,
	22 05	67	,, 1·2 sec.	,,
	22 10	68	,, 2·6 sec.	,,

* Times when fish was put in apparatus and removed.
† No S. signifies no electric shock given (see text p. 366).

body movement, is delayed by a short period varying from a fraction of a second to 2–3 seconds. At least 0·2 second of this is definitely due to time-lag in the recording mechanism, and it would seem that in those instances where the recorded response takes place at 0·2 second after the application of the conditioning stimulus that the result approximates closely to the demands of the above postulate. More elaborate technique is necessary to give a satisfactory answer to this aspect of the experiments.

It has not been thought necessary to give the full details of the experiments, but one typical log is given as an example (Table I, *Spinachia vulgaris* (L)). This shows the salient features of all the experiments, the remainder of which are summarised in the succeeding table (Table II).

TABLE II.

Summary of Present Series of Experiments on Several Teleostean Fishes showing the Variation in their Ability to Associate the Visual Stimulus of a Circle of Magenta Light with an Electric Shock.

Species.	No. of associations before 1st appearance of the conditioned response.	Percentage of positive responses to light alone after the 1st appearance of the c.r.	Latent period of response. General statement. Seconds.	Total number of associations in experiment.
1. *Cottus bubalis* Euphrasen .	37	100	0·5–3	93
2. *Spinachia vulgaris* Flem. .	18	96	0·2–3	69
3. *Onos mustela* (L.) . .	17	100	0·4–4	52
4. *Liparis montagui* (Donovan)	16	92	0·2–4	64
5. *Zoarces viviparus* L. . .	34	92	0·8–4	87
6. *Centronotus gunnellus* (L.) .	36	77*	0·6–4	90
7. *Rhombus maximus* L. . .	Not formed	—	—	233
8. *Pleuronectes platessa* L. .	,,	—	—	203
9. *Pleuronectes flesus* L. . .	,,	—	—	203

It is to be seen that the three Pleuronectid fishes have reacted in a manner markedly different from the remainder, and that they have been found incapable of forming a conditioned response under these conditions for at least 200 associated presentations, whilst the other fishes have done so in less than 40 such presentations. In addition it has already been extensively shown (Part III) that *Blennius pholis* readily forms this response in a comparatively short number of trials; so, too, with *B.*

* 100% after the 66th association.

gattorugine (Part I, pp. 527 *et seq.*). Further, consistently negative results for over 200 trials were obtained in an earlier (unpublished) experiment with a small turbot (*Rhombus maximus*) where light was similarly used as a conditioning stimulus in association with a sharp tap with a pointed glass rod.

On the other hand, in contrast with these results with a harmful unconditioned stimulus, it has been shown that where a visual conditioning stimulus is used in association with a harmless one such as a *food*, no real difficulty is experienced in establishing associative behaviour in Pleuronectids (Part II, p. 620). At the same time attention has already been drawn to a distinctive feature in the behaviour of Pleuronectids in that type of experiment which appears to harmonise with the present observations (Part II, p. 621).

It is here that the study of the organism in the field recently emphasised by E. S. Russell (**5**) helps to throw light. Pleuronectids in general are peculiarly well adapted to escape from enemies by a mechanism of concealment comprising (*a*) adaptation to colour of background; (*b*) "freezing" or keeping still (so far as is practicable) when alarmed. This behaviour is well known to all who have pushed a shrimp net along a sandy shore after flat-fishes.

The other fishes used in these experiments all exhibit, with or without modification, a well-marked "flight" reaction when alarmed. It is concluded, therefore, that the *normal* reaction of these respective types of fish to a harmful or threatening stimulus exercises a controlling influence over the *experimental* formation of conditioned motor responses when these are investigated on the basis of a similar stimulus (i.e. an electric shock). In looking for an explanation of the nervous mechanisms involved in conditioned behaviour this correlation provides something definite upon which to build.

It also follows that Pleuronectid fishes are unsuitable for the investigation of visual discrimination by conditioning on those lines, but that no difficulty should be experienced with the other fishes mentioned.

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SUMMARY.

Normal behaviour traits control the ability of fishes to form conditioned motor responses. This is shown by a series of experiments upon various species of fish in which it is found that Pleuronectids are found incapable of forming such responses for at least 200 associated presentations whilst other fishes have done so in less than 40. The bearing of the results on current theories of animal learning is briefly discussed.

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