Higher Order Conditioning with Constant Motivation
Author(s): Glen Finch and Elmer Culler
Source: *The American Journal of Psychology*, Vol. 46, No. 4 (Oct., 1934), pp. 596-602
Published by: University of Illinois Press
Stable URL: https://www.jstor.org/stable/1415498

HIGHER ORDER CONDITIONING WITH CONSTANT MOTIVATION

By GLEN FINCH and ELMER CULLER, University of Illinois

Pavlov, citing the experimental data of Foursikov, declares that conditioned reflexes cannot be established beyond the third order. "It was," he says, "found impossible in the case of alimentary reflexes to press the secondary stimulus into our service to help us in the establishment of a new conditioned stimulus of the third order. Conditioned reflexes of the third order can however be obtained with the help of the second order of conditioned reflexes in defence reactions such as that against stimulation of the skin by a strong electric current. But even in this case we cannot proceed further than a conditioned reflex of the third order."[1]

The question arises, whether this failure to establish conditioned responses beyond the third order may be due to failure to maintain adequate "motivation" in the animal rather than to any inherent difficulty of the problem itself. Consider the experiment of Foursikov: Stimulus A (electric stimulus to the skin over the front paw) is the primary or unconditioned stimulus which evokes a defence reaction in the dog; stimuli B (mechanical irritation of the skin over the hind paw), C (sound of bubbling water), and D (760-cycle tone) are indifferent stimuli which evoke no defence response in the animal. The stimulus-combination B + A is repeatedly presented to the animal until B is converted into a conditioned stimulus of the first order. Now the combination C + B is repeatedly presented until C alone evokes the defence reaction (C thus becomes a conditioned stimulus of the second order) ; in the same way the repetition of D + C converts D into a conditioned stimulus of the third order. Repetition of a fifth stimulus E with D does not result in the establishment of E as a conditioned stimulus. The establishment of B as a conditioned stimulus depended upon its becoming related to the defence response of the animal evoked by stimulus A through the repeated presentation of B along with A. In the same way C and D were able to evoke the defence reaction only by virtue of their relationship to A through B. Thus C is one step more remote from A than is B,

* Accepted for publication August 6, 1934. Communication No. 11 from the Alpha Laboratory for Animal Hearing, established and maintained with aid from the Research Trustees, American Otological Society. Special aid from the Elizabeth Thompson Science Fund is gratefully acknowledged.

[1] I. P. Pavlov, *Conditioned Reflexes*, 1927, 34.

and D is one step more remote than is C; it seems reasonable to assume that the kinship between A and D is less than that between A and C, which is also less than that between A and B. The failure to establish E as a conditioned stimulus might then very well be attributed to the fact that its relationship to A through D, C, and B is too weak for it to become effective in educing the response natively elicited by A. Plausibility is loaned to this explanation by the fact that Foursikov noted a definite gradient of the strength of the responses to the different orders of conditioning; he found that the response to B was stronger than that to C, and that the response to C was stronger than that to D.

The present investigation was designed to determine whether conditioning beyond the third order is possible when the *motivation* of the animal is maintained through the various orders. Our hypothesis, in brief, is that failure to condition at higher levels is due to a failure of the incentives which normally serve to activate the animal's response.

Procedure. Two dogs were used in this experiment; one was a male German Shepherd (age 18 mo.), the other a male mongrel German Shepherd (age 12 mo.).

The unconditioned response consists in withdrawal (flexion) of right foreleg when shock is applied to paw; conditioned stimulus of the first order is a loud 1000-cycle tone (intensity about 70 decibels above the limen); of second order, electric light; of third order, stream of water on nose; of fourth order, electric bell; and of fifth order, electric fan playing on the animal. In addition to these, a general energizing stimulus was employed (shock to left thorax,[2] administered whenever animal fails to flex leg and omitted upon each correct response). The animal was confined in a stock in a soundproofed test-room. All stimuli were automatically delivered to the animal by electric controls; their duration was timed by means of a synchronous motor which operated the contact-apparatus. Every one of the 5 unconditioned stimuli was 2 sec. in duration and each of the electric shock-stimuli about 1/4 sec.

The conditioned response to the first order stimulus (tone) was first thoroughly established in the usual way (*i.e.* 2-sec. sound immediately followed by shock to paw, until animal learned to flex the leg before the grid was charged). Next the second-order stimulus (light) was presented concurrently with the first-order; but now the shock was applied, not to the forepaw as heretofore, but to the left side of thorax. Just as the animal could escape the shock-to-paw by lifting the foot, so now it could escape the thoracic shock by lifting the foot and thus breaking the shock-circuit. After

[2] The thoracic shock was administered quite automatically, not by a decision of *E*. The animal's forelegs were fastened each to the end of a short lever with but one degree of freedom (up-down). A leather strap, provided with two metal contact-points which pressed into the skin, was bound around the thorax. Leads passed from these contacts to a mercury-in-glass switch so attached to the right lever that the right leg could not be flexed without breaking the mercury-contact and thus opening the shock-circuit. In this way a very definite and uniform incentive was provided at all levels: punishment upon failure to respond. This incentive did not become, as in Foursikov's case, increasingly remote from the higher-order stimuli, but persisted throughout as a *constant* energizing agent.

the response had been established to the light alone, the third-order stimulus (stream of water on nose) was presented together with second-order (followed by thoracic shock) until the animal responded to the stream of water alone. The fourth-order stimulus (electric bell) was next presented with the third, and the fifth (electric fan playing on animal) with the fourth. It should be emphasized that shock-to-paw was the *only* one of all these stimuli that was capable of evoking the flexion-response prior to training.

TABLE I

SHOWING RESULTS FOR DOG I

Column A, test-period; Column B, stimulus-combination; Column C, ratio of correct responses to total trials for test-period, *e.g.* 24/25 means the animal responded 24 times in 25 trials.

A	B	C	A	B	C	A	B	C
1	SL	21/25	14	SL	5/5	25	WB	5/5
	L	0/14		L	21/25		B	17/25
2	SL	25/25	15	SL	5/5	26	WB	10/10
	L	5/12		L	25/25		B	12/25
3	SL	25/25	16	SL	12/12	27	WB	10/10
	L	10/10		LW	5/25		B	23/25
4	SL	25/25	17	SL	11/11	28	B	21/25
	L	10/10		LW	9/25	29	B	25/25
5	L	17/20	18	SL	5/5	30	B	25/25
6	L	20/25		LW	9/10	31	BF	10/10
7	L	17/25		W	7/10		F	11/20
8	L	19/25	19	LW	5/5	32	F	25/25
9	L	17/25		W	21/25	33	F	25/25
10	SL	24/25	20	LW	7/10	34	F	25/25
	L	10/10		W	18/25	35	F	25/25
11	SL	5/5	21	LW	5/5	36	F	25/25
	L	24/25		W	24/25	37	F	25/25
12	SL	5/5	22	W	23/25	38	F	25/25
	L	19/25	23	W	25/25			
13	SL	5/5	24	WB	5/5			
	L	25/25		B	3/15			

Results. Table I presents the material from Dog I. In the second column, "S" signifies the 1000-cycle sound stimulus, "L" indicates electric light-stimulus, "W" indicates the squirt of water on the animal's nose, "B" indicates electric bell-stimulus, and "F" represents the electric fan-stimulus. The stimulus-pattern "SL" indicates that the tone and light were presented simultaneously, "LW" that the light and water were presented together, and so on. The third column shows the ratio of responses to the number of times the given stimulus pattern was presented during one training period. Table II presents the data of Dog II.

Discussion of results. The most obvious difference between our procedure in the present experiment and that of Foursikov is the introduction of the thoracic shock. It is here that our discussion must center. Two fundamental questions arise. (1) Is the thoracic shock a native or unconditioned stimulus to flexion of the right foreleg? From careful and repeated observation of various animals, we find that the thoracic shock when applied to an utterly naïve dog which has never been in the training situation before, evokes a response which includes these elements: quick gasp or yelp; wincing away from electrodes; sudden sag or slump of hind limbs, particularly the homolateral one; strong adduction of tail. One or more of these will occur at once, directly followed by whining or barking, biting or gnawing at nearby objects, and frequently a general struggle to escape (twisting, jerking, pulling). In this struggle the dog will often try to free both forelegs from the attached levers; but these vigorous flexions are of course determined by the general somatic activity and are in no sense a specialized response. The exact pattern depends on the force of the shock; but we have yet to see a single case which could be interpreted as a specific or localized response of either foreleg to the thoracic shock. We feel warranted therefore in answering this question with an assured negative. (2) But is not the thoracic shock, more probably, a conditioned or substitute stimulus? The best answer to this is found in a note from our protocols, made over six weeks after the two animals, Dogs I and II, had been working with the thoracic shock. At this time, Dog I had received, under test-conditions, by

TABLE II
Showing Results for Dog II

A	B	C	A	B	C	A	B	C
1	SL	17/20	15	SL	8/8	26	WB	5/5
	L	4/8		L	20/25		B	1/15
2	SL	24/25	16	SL	5/5	27	WB	5/5
	L	9/14		L	25/25		B	18/25
3	SL	25/25	17	SL	8/8	28	WB	10/10
	L	10/10		LW	18/25		B	7/25
4	SL	25/25	18	SL	20/20	29	WB	10/10
	L	10/10		LW	12/25		B	17/25
5	L	25/25	19	SL	5/5	30	B	19/25
6	L	23/25		LW	10/10	31	B	19/25
7	L	18/25		W	10/10	32	B	15/25
8	L	21/25	20	SL	5/5	33	B	25/25
9	L	11/25		LW	10/10	34	BF	6/10
10	L	16/25		W	10/10		F	19/50
11	SL	25/25	21	LW	5/5	35	F	24/25
	L	10/10		W	16/25	36	F	24/25
12	L	11/25	22	LW	5/5	37	F	24/25
13	SL	5/5		W	21/25	38	F	25/25
	L	14/25	23	LW	5/5	39	F	25/25
14	SL	5/5		W	24/25	40	F	25/25
	L	25/25	24	W	25/25	41	F	25/25
			25	W	25/25	42	F	25/25

actual count 193 thoracic shocks, and had brought his responses to all four conditioned stimuli (second, third, fourth, fifth) up to 100%. Dog II had received 217 thoracic shocks and had reached 100% on second, third, fourth orders and 68% on fifth order. At this stage the following test-observations were made and recorded: "*Neither Dog, I nor II, lift right forepaw upon receiving shock on left thorax* even though they have by this time received it many times. Their reactions to thoracic shock alone are: quick gasp, crouching of whole body (hind legs slump), general bodily tremor, occasional urination and vomiting." In view of this evidence we feel justified in stating that the thoracic shock *does not tend to become* a conditioned or substitute stimulus for withdrawal of the paw. This evidence has been fully confirmed on at least 5 other dogs used in a later problem, which have been specifically tested on this point many times. In no case have they developed any tendency to react to the thoracic shock alone by foot-withdrawal. Accordingly we answer this second question also with a definite negative. To the question, why did not the thoracic shock become a substitute stimulus for flexion, the most obvious answer is, that it always followed the other stimuli and that this temporal position does not favor conditioning.

There is every indication that we might proceed indefinitely to still higher orders. Dog I needed only 10 trials for conditioning to the fifth stimulus (fan); thereafter he reacted 186 times in 195 trials. Dog II likewise after 10 combinations (B + F) reacted 216 times in 250 trials with the fifth stimulus. This proves beyond any doubt that the conditioning is not slowing down at the higher levels; on the contrary it seems to be speeding up. There is every reason to believe that higher order conditioning by this method is limited only by the number of available stimuli.

It should be noted that the primary stimulus (shock to paw) was *never* applied to either animal during the entire higher order conditioning period (42 days), and the fifth order conditioning was maintained at maximal strength for 175 trials in the one dog and for 125 trials in the other without reënforcement of any kind other than the thoracic shock. In view of these facts and since it has been demonstrated that the thoracic shock never acquired the status of a conditioned stimulus; and since the reactions elicited by its application alone (quick gasping intake of breath, crouching of whole body, somewhat general bodily tremor) are apparently not confined to any particular muscle group but are more general in character; the conclusion seems justified that the thoracic shock functions as a general motivating or activating stimulus.

In conclusion, we may remark that this material seems to clarify certain alleged discrepancies between the mechanisms of everyday learning and those which operate in animal conditioning. Theorists have long been disturbed by the need for repeated, well-nigh incessant, reënforcement of the conditioned response by the original stimulus. This one fact seems sharply to differentiate the two phenomena of learning and conditioning. It is clear that the growing child builds up a complex super-structure of acquired knowledge and skills, adding one substitute stimulus to another in endless sequence, with no need for repeated backward reference to some early avoidance or acceptance, no constant revival of some positive or negative response which stands at the head of the line. A conditioned animal, on the contrary, cannot seem to get away by more than one or two steps from the unconditioned stimulus which initiated the series. In consequence, there is something undeniably meager and tenuous about ordinary conditioned responses; they lack range, stability, and depth.

We feel that the simple experiment herein described has provided a satisfying explanation of this difficulty. Consider a simple, schematic case.

(A) Contact with candle-flame→withdrawal: original unconditioned.
(B) Look out! (spoken): first order conditioned.
(C) Look out! (printed): second order conditioned.
(D) Wet paint: third order conditioned.
(E) *Achtung!* fourth order conditioned.
(F) Sterile surgical field: fifth order conditioned.

The process continues step by step: A + B eventuates in a negative response to the warning cry, "Look out;" B + C gives the printed words "Look out" similar negative value; C + D keeps the child from sitting on wet paint; D + E gives negative significance to the German warning, *Achtung!* E + F finally makes the child careful of a sterile field. It is clear that the painful heat of the candle-flame years ago has nothing to do with this later continuance of the negative responses. We do not avoid wet paint because we fear being burned by it. The factors which serve to keep these responses alive are directly analogous to the thoracic shock in the dog; such things as parental stimulation, the code among playmates, emulation and rivalry, the rewards and penalties imposed by social discipline—all the many incentives commonly used to promote learning in children. The person whose hand carelessly violates a surgical field has future avoidance just as thoroughly reënforced by social devices as though his fingers were burned again. If the process of learning in the human had to draw its whole sustenance from the primitive response to pain or to food, it would fade out precisely as conditioning does in the dog when we proceed too far from the source of drive or energy. As soon as activation becomes subliminal, the response fails in human as in dog. Though the child be exposed in turn to countless substitute stimuli as it grows and learns, the incentives which society maintains are the really significant factors. It is these incentives which, like the thoracic shock, enable learning to continue for years. In our procedure the only critical place is the transfer from direct shock-to-paw to the more indirect thoracic shock. Some animals require time to get over this gap; but the gap once bridged, everything proceeds routinely thereafter. Likewise we see children who have difficulty in passing from the immediate incentives of pain or food to the less obvious incentives of social approval or rejection.

CONCLUSIONS

(1) Motor conditioning (flexion of paw) has been carried as far as the fifth order when animal is adequately energized. There is every reason to infer that the process could be carried on to any desired level.

(2) A shock to the left thorax provides the incentive or motivation needed to keep the animal responding. This activating shock is not an unconditioned stimulus, nor does it become a conditioned stimulus, for the motor response.

(3) The flexion response can, under these conditions, be maintained for long periods of time (at least for six weeks) without a single reënforcement by the primary stimulus (shock-to-paw).

(4) The thoracic shock serves much the same purpose in the dog as do ordinary social incentives in everyday human learning.