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FACILITATION OF INSTRUMENTAL AVOIDANCE LEARNING BY PRIOR APPETITIVE PAVLOVIAN CONDITIONING TO THE CUE

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The interactions between Pavlovian conditioning and instrumental behavior are of considerable importance to the development of a more adequate general theory of learning and behavior. Assessments of these interactions have usually been made by presenting a Pavlovianly conditioned stimulus while the subject is engaged in some instrumental task. The outcomes of such experiments depend on a variety of factors, important among which are the nature of the Pavlovian stimulus (CS+ or CS−), the nature of the Pavlovian UCS (alimentary or defensive), and the nature of the instrumental reinforcer (positive or negative) (Rescorla and Solomon 1967).

In experiments using homogenous combination of reinforcers, that is where the reinforcers used in both the Pavlovian and instrumental procedures are either both appetitive (food) or both aversive (shock), presentation of the Pavlovian stimulus typically resulted in facilitation of the instrumental behavior during the CS+ and suppression during the CS− (Rescorla and LoLordo 1965, Morse and Skinner 1958). Heterogeneous combinations (where opposite types of reinforcers are used, food in one, shock in the other and vice versa) have in most cases had the opposite outcome; that is, the CS+ resulted in suppression of instrumental responding while the CS− either facilitated the instrumental response or had no significant effect (Bull 1970, Grossen et al. 1969, Hammond 1966).

These interactions have been accounted for by reference to two-process learning theory which asserts that Pavlovianly conditioned mediators control instrumental responding (Rescorla and Solomon 1967), the proposed mechanism by which these mediators make contact with the instrumental responses being a motivational one. The heterogeneous

interactions noted have frequently led to the further assumption that a reflex mutual incompatibility exists between appetitively and aversively based mediational states; the occurrence of an elicitor or inhibitor of fear is assumed to reflexly depress or enhance, respectively, positive incentive motivation, and the occurrence of an elicitor or inhibitor of positive incentive motivation is assumed to reflexly depress or enhance, respectively, fear motivation. Konorski (1964) independently has proposed a similiar two-process theory emphasizing two separate motivational centers (alimentary and defensive) which are reciprocally inhibitory, and Stein (1964) has also argued persuasively that there is a reciprocal antagonistic interaction between the central mechanisms for rewerd and punishment.

Rescorla (1969) in a thorough review has indicated that there are two general techniques for revealing inhibitory influences: (i) a summation procedure in which an inhibitor reduces the response that would normally be elicited by another stimulus and (ii) a retardation-of-acquisition procedure in which the inhibitory stimulus is retarded in the acquisition of control of an excitatory response. Results from these two techniques should be consistent (as described) if either effect is to be attributed to an inhibitory interaction. If these theories are correct and the suppression of responding observed in the heterogeneous Pavlovian $\rightarrow$ instrumental interaction experiments is due to an incompatibility (inhibitory interaction) of appetitively and aversively conditioned motivational states, then we should be able to demonstrate this incompatibility by both experimental techniques. With respect to heterogeneous interactions, the above reviewed experiments used the summation technique and their results have been consistent with the inhibitory reflex interrelation hypothesis. Therefore, if an appetitive CS+ elicits a mediational state which is incompatible with aversive motivation (fear), then it should be more difficult to establish a stimulus as a cue for avoidance if it has previously been established as a Pavlovian CS+ for food. This experiment tests this retardation-of-acquisition hypothesis.

MATERIAL AND METHODS

Subjects

The *S*s were 24 mongrel dogs obtained from the University Animal Hospital; these had ad lib weights of 12 kg $\pm$ 2 kg and were 38 to 48 cm tall at the shoulder. Prior to any of experimental treatments, *S*s were reduced to approximately 80% of ad lib body weight by deprivation and a 24 hr feeding schedule, and were maintained at this weight level

throughout the experiment. *S*s were arbitrarily assigned to one of three equal groups.

Apparatus

Two different apparatus units were used — one for the appetitive Pavlovian conditioning and one for the instrumental training.

The Pavlovian conditioning apparatus consisted of a 85 × 43 cm wooden platform suspended 75 cm above the floor by a pipe frame inside a dimly illuminated, sound reducing cubicle. The pipe frame extended 30 cm above the platform and provided an enclosing rail. A flat U-shaped aluminum tray was mounted to the frame beneath *S*'s head and extended 33 cm forward and 24 cm to either side. Supported on the tray was a food cup 2 cm deep and 14 cm by 19 cm into which food pellets were automatically dispensed from a rotary feeder via a 55 cm chute. *S*'s movement was restricted by light chains from their dog collar to both sides of the frame and to the ceiling. Speakers were attached to the rear wall of the cubicle and were used to present two auditory CSs (275 Hz or 2300 Hz impure sine wave tones) at approximately 10 db (re: 0.0002 dynes/cm^2) above the 70 db background white noise.

The instrumental training apparatus was a two-way shuttlebox separated by an adjustable barrier and a retractable response preventing drop-gate. Each compartment was 1.16 × 1.02 × 0.63 m high with ceilings of expanded metal grating. Above each compartment were 150 w lamp and two speakers. One speaker provided a background white noise of approximately 70 db, while the other was used during the avoidance acquisition phase to present the auditory cue (either 275 Hz or 2300 Hz). Electric shock was administered through a grid floor of 3.1 cm flat aluminum bars placed 1.7 cm apart. A scrambler shifted polarity patterns of the bars six times per second. Shock was 4.5 ma delivered through a current limiting resistor of 100,000 ohms in series with *S*. Responses were detected by two photocells located 35 cm above the grid floor and 28 cm on each side of the barrier. Trial duration and response latencies were measured to the nearest 0.01 sec using an electric timer.

Stimulus presentations and contingencies for both apparatus units were controlled by automatic relay circuitry.

Procedure

Each *S* received the following sequence of treatments: adaptation and magazine training, escape training, discriminative appetitive Pavlovian conditioning, and instrumental avoidance training. All treatments were administered on successive days.

Adaptation and magazine training. All *S*'s received adaptation and

magazine training in the Pavlovian conditioning cubicle. This consisted of fixing *S* in the harness and presenting 15 food pellets, Gaines "Prime", singly with a mean intertrial interval (ITI) of 80 sec (range 40–120 sec). This was continued until all pellets were seized and eaten promptly upon delivery. All subjects received either 4 or 5 days of this treatment.

Escape training. Each *S* was then trained to escape unsignaled shock by jumping a shoulder high barrier in the two-way shuttlebox. Ten trials a day were given on two consecutive days. The escape trials were presented with a VI 80 sec ITI; shock remained on until *S* performed the requisite response or until 60 sec had elapsed. The drop-gate was raised throughout this phase. The purpose of this escape training was to insure that all *S*s would uniformly have short escape latencies in the later avoidance training phase. Mean escape latencies on second day were 4.70, 4.26, and 2.92 sec for the CS+, CS^0, and CS− groups, respectively; these did not differ significantly (Kruskal–Wallis $H = 3.64$, $df = 2$, $p > 0.10$).

Pavlovian conditioning. Following escape training *S*s were returned to the cubicle. There the two experimental groups received 7 days of discriminative appetitive Pavlovian conditioning. Although both groups were treated identically in this phase, one was designated as the CS+ group and one as the CS− group. On each day each *S* received 15 CS+ and 15 CS− trials in a random sequence according to a VI-80 sec schedule. On a CS+ trial, a 10 sec tone terminated with presentation of a single food pellet; on a CS− trial, the contrasting tone was presented for 10 sec but was never followed by food. Which pitch was assigned as CS+ was counterbalanced within each group.

The control group, designated as CS^0 group, received exactly the same number of food and tone presentations at the same temporal intervals as the experimental *Ss* but there was no contingency between tones and food. On each of 7 days, fifteen food presentations were given on a VI 160 sec schedule but randomly and independently with respect to 15 10-sec presentations of each of the two tones; the tones were presented randomly according to a VI 80 sec schedule.

Instrumental avoidance training. In this final phase, all *S*s were trained to avoid shock by jumping the shuttlebox barrier in response to an auditory S^D. The three groups differed only in what stimulus was selected to function as the S^D. For the CS+ group, the tone which had signaled food in the Pavlovian phase was used as the S^D, while for the CS− group, the tone which had signaled "no food" was used as the S^D. For the CS^0 group, neither tone had any consistent relation to food and for one half the *S*'s the low tone was used as the S^D while for the remainder the high tone was used.

An avoidance training trial began with the raising of the drop-gate and the onset of the S^D. The S^D-shock onset interval was 10 sec. A barrier-crossing response made during the S^D-shock onset interval prevented shock and terminated the S^D. Later responses terminated both the S^D and shock. To prevent intertrial responses, the drop-gate was lowered over the barrier between trials. Twenty trials were presented each day using a VI-80 sec ITI until a criterion of 10 consecutive avoidances was met. All *Ss* received a minimum of 20 avoidance training trials even if they met the learning criterion prior to the 20th trial.

RESULTS

The instrumental avoidance training phase provided a test of the influence of the appetitive Pavlovian history of a stimulus upon subsequent avoidance response learning to that stimulus. Therefore, indices of avoidance acquisition are the data of interest. Because some *Ss* met the avoidance learning criterion during the first 20 trial session, only this session was analyzed extensively.

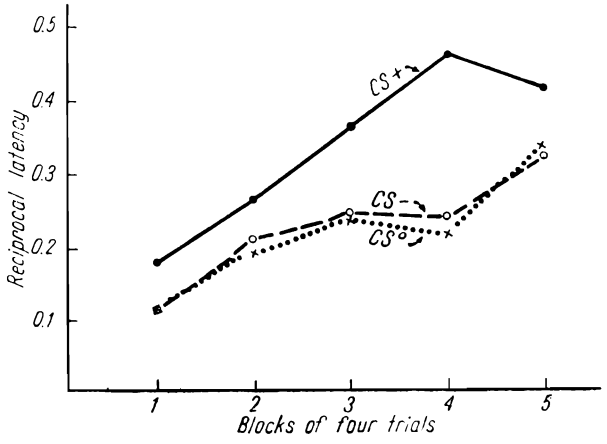

Fig. 1. Mean reciprocal avoidance response latencies to the cue for avoidance during the first avoidance training session. The groups differ in and are designated by the appetitive Pavlovian conditioning history of the cue for avoidance.

On these early trials, avoidance performace was facilitated when the CS+ which formerly signaled food was used as the cue for avoidance. Non-parametric analysis of variance showed that the groups differed in their mean reciprocal latencies (speeds) of response to the cue for avoidance (Kruskal–Wallis $H = 6.24$, $df = 2$, $p < 0.05$); these data are present-

ed in Fig. 1 broken down into five blocks of four trials to show the course of acquisition. Whitney's extension of the U-test (Mosteller and Bush 1954) confirmed that the CS+ group responded more quickly than both the CS⁰ group and the CS− group ($h = -2.6$ and -2.0, respectively, $p < 0.01$) [1].

Similarly, the groups differed in the number of avoidance responses the CSs evoked during the first twenty trials ($H = 6.76$, $df = 2$, $p < 0.05$); these data are presented in Fig. 2 also broken down into five blocks of

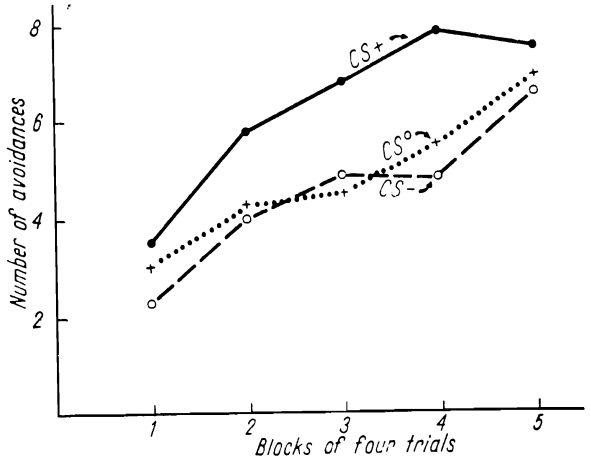

Fig. 2. Mean number of avoidance responses per trial for each group to the cue for avoidance during the first avoidance training session. A mean value of 8 represents 100% avoidances. The groups differ in and are designated by the appetitive Pavlovian conditioning history of the cue for avoidance.

four trials to show acquisition. Again, Whitney's extension of the U-test confirmed that the CS+ group avoided reliably more often than both the CS⁰ group and the CS− group ($h = -1.6$ and -2.7, $p < 0.01$).

Additional indices of acquisition are presented in Table I. Although only some of these reveal the CS+ group to differ significantly from *both* the CS⁰ and the CS− groups (Whitney's extension of the U-test, $h \leqslant -0.9$ for $p < 0.05$), they all confirm the generally superior avoidance performance of the CS+ group.

[1] Similar analyses applied to mean and median latencies yielded statistical comparisons essentially identical to those for speeds ($H = 5.56$, $p \simeq 0.06$, and $H = 6.70$, $p < 0.05$, respectively; $h = -1.7$ and -2.2, $p < 0.01$, and $h = -2.0$ and -2.1, $p < 0.01$ respectively).

TABLE I

Additional avoidance acquisition indices

Index	Group		
	CS+	CS^0	CS−
Trials to first avoidance	2.25	3.38	4.38
Trials to 3 consecutive avoidances*	8.00	14.38	14.50
Trials to 5 consecutive avoidances*	11.88	17.88	17.00
Percentage shocks to 5 consecutive avoidances*	31.20	39.70	46.66
Trials to criterion	21.50	27.10	23.90
Percentage shocks to criterion*	20.50	30.11	36.84

* $p < 0.05$.

DISCUSSION

The group for which the cue for avoidance had been previously established as a signal for food (appetitive Pavlovian CS+) acquired the avoidance response most rapidly.

This outcome was contrary to our expectations based on the summation studies. The same appetitive conditioning procedure which produces a CS which suppresses responding in an on-going avoidance task as has been demonstrated by Bull (1970) and others results in a CS which facilitates the acquisition of that same avoidance response. Just why we failed to find retardation of acquisition results which are consistent with the summation results is not clear.

Our results also are not consistent with those of an earlier experiment, Konorski and Szwejkowska used an appetitive Pavlovian CS+ empirical basis for Konorski's two-process theory (Konorski 1964, Konorski and Szwejkowska 1956) which invoked two reciprocally inhibitory motivational centers. In a two-stage all Pavlovian heterogenous experiment, Konorski and Szwejkowska used an appetitive Pavlovian CS+ and CS− as the CS+ for aversive Pavlovian conditioning of a leg flexion response. In contrast to the ease with which the appetitive CS− was transformed into an aversive CS+, the appetitive CS+ elicited only weak and unreliable defensive conditioned responses even after many trials. However only one dog was exposed to this condition and it had a long history of prior conditioning and extinction — some with the same stimuli used in this last test. Consequently, our confidence in the present results obtained with several naive *S*s is not shaken by this discrepancy.

Our results do, however, bear on the interpretation of findings from

other studies where the presentation of appetitive signals has resulted in suppression of avoidance responding. While such suppression results might possibly be interpreted in terms of an inhibitory effect by the CS+, it must be done with caution since the same Pavlovian procedures do not result in a stimulus which interfers with acquisition. Appetitive Pavlovian stimuli should both suppress avoidance responding *and* retard acquisition of avoidance responding if we are to accept the theoretical notion that appetitive and aversive conditioned motivational states interact inhibitorily. To some extent then, the present experiment reduces our confidence in the subsidiary assumption af two-process theory that Pavlovian conditioned mediators make contact with the instrumental response via reciprocally inhibitory appetitive and aversive conditioned motivational states. To this extent, we must look for other mechanisms to account for the full range of Pavlovian conditioning → instrumental responding interactions.

How are we to explain the accelerated acquisition of avoidance responding to a cue which was formerly an appetitive CS+? One possible explanation might be in terms of proactive facilitation of learning through something like the "learning sets" phenomenon in Pavlovian conditioning. Perhaps just having prior experience with a CS as a signal of some consequence augments its subsequent use as a discriminative signal regardless of the hedonic nature of reinforcement with which it is paired. Alternatively various attentional mechanisms may be involved. None of these, however, fall within the bounds of two-process theory as currently characterized.

In summary, our finding was that the use of an appetitive CS+ as a cue facilitated the acquisition of an avoidance response. This outcome does not support the explanation that suppression of avoidance behavior by an appetitive CS+ is due to some inhibitory effect.

SUMMARY

Three groups of eight dogs were trained in an instrumental avoidance response (type II) using a Pavlovianly conditioned (type I) appetitive CS+, CS^0, or CS− as the avoidance cue. Contrary to expectations, the formerly appetitive CS+ facilitated acquisition of the avoidance response when compared to the CS^0 and CS− groups.

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