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Thirst and shock-escape drive interaction

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THIRST AND SHOCK-ESCAPE DRIVE INTERACTION
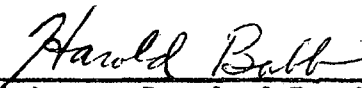
By

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I. INTRODUCTION & STATEMENT OF PROBLEM

In the experimental laboratory much research has been done to investigate the effects of single drives on learning and performance. However, relatively little research has been devoted to finding how learning and performance are influenced by multiple drives and how these drives interact. It seems probable that a large proportion of complex human behavior is influenced by more than one drive.

The fact that drives do interact has long been known. For example, Moss (1924) noted that sex drive decreased under conditions of food deprivation. Likewise Warner (1928) found that rats in free-feeding situations ate less when they were water-deprived. Verplank & Hayes (1953) confirmed this latter finding and in addition found that food-deprived rats drank significantly less water than did non-deprived controls.

The primary impetus for the research into the effects of multiple drives seems to have come from Hull's (1943) formulation of the drive summation hypothesis. In essence it states that the total effective drive is a summation of all the relevant drives plus all of the irrelevant drives. Much research (Amsel, 1950; Broadhurst, 1957; Ellis, 1957; Ishii, 1965; Kendler, 1945; Siegel & Siegel, 1949) has been done to substantiate or to disprove this hypothesis, but as of yet, its validity is still uncertain.

Studies similar to this one, in that they were concerned with the combination of two relevant drives, present a somewhat ambiguous picture. Most have shown a combination of drives to have an

additive effect (Elliot, 1929; Matsuyama, 1960; Morey, 1934; Porter & Miller, 1957). A few studies, however, have either suggested a possible suppressive effect or have failed to find additivity (Harlow, 1950; Muenzinger & Fletcher, 1936; Powloski, 1953). All of these experimenters used a combination of two appetitive drives except Matsuyama (1960) and Morey (1934) who used two aversive drives, and Muenzinger & Fletcher (1936) who used one appetitive and one aversive drive.

In one very important aspect this experiment differed radically from all the previously mentioned ones. All of the others were concerned with the immediate effect on performance of two simultaneous drives. This experiment, in contrast, was primarily concerned with the subsequent effect on performance under a single drive after initial learning under two simultaneous drives.

From his work with compound conditioned stimuli, Pavlov (1927) concluded that compound stimuli obscure each other and that the degree of obscurement is a function of the difference in the strengths of the stimuli. Although Pavlov (1927) based his conclusions on experiments in which the compound conditioned stimuli were presented through only one sense modality, he believed that his conclusions would also be valid for compound stimuli presented through different sense modalities.

According to Estes' (1959) formulation of learning theory, the stronger a stimulus is, the more likely elements from it will be

sampled on any given trial. Extending this hypothesis, it would seem that if a $\underline{S}$ learns a single response in the presence of two stimuli, then the response will be more strongly connected with the stronger stimulus. Suppose for example that one group of rats were trained to run down an alley under simultaneous conditions of strong thirst and weak shock and that another group were similarly trained under conditions of weak thirst and weak shock. Then suppose that both groups were continued on weak shock alone. Estes' theory would seem to predict that the group in which strong thirst was dropped would be slower as a result of a greater amount of the original stimulus complex having been eliminated. In other words, the strong thirst group should more strongly come to associate running with thirst cues than the weak thirst group would, and as a consequence should run more slowly when these thirst cues are removed.

Though the theoretical rationale for this experiment was first conceived by the author within an Estesian framework, it is true that the same predictions should follow from a Hullian point of view. In fact, a Hullian model seems to handle the facts as well without as many assumptions. Basically, the process of switching from two drives to one, may be conceived as an example of stimulus generalization. Take the example used in the last paragraph. The rats which had strong thirst dropped would be experiencing greater change from the training conditions than would those which had weak thirst dropped. From a stimulus generalization point of view as

expounded by Hull (1943), one would predict that the former group
would perform more poorly.

In a recent series of experiments, Babb (1963); Babb, Bulgatz,
& Matthews (in press); and Babb & Leask (in press) transferred rats
from shock-motivated to thirst-motivated or hunger-motivated training
in a straight runway. In comparison with non-shock controls, they
have found a suppressive effect on both starting and running speeds.
It also appears that the greater the amount of shock, the greater
the amount of suppression. They suggest that the suppressive effect
may be due to a conflict between different patterns of responses
learned under appetitive and aversive conditions.

In view of prior research, particularly that of Pavlov (1927),
Hull (1943), Estes (1959), and Babb et al. (in press); it seemed
possible that simultaneously subjecting subects to thirst and pain
might result in values of the dependent variables, in later transfer
to a single drive condition, which would be less than if either of
the drives had been used alone. In addition it was believed that
the stronger one type of drive is, the greater the suppressive
effect it may have on the attachment of responding to drive stimuli
of the other type. It is this last hypothesis that this experiment
was specifically designed to test.

II. METHOD

Subjects

Subjects were 56 male hooded rats that were obtained from Simonsen Laboratories of Gilroy, California. They were approximately 65 days old on the first day of pretraining. After pretraining, 48 of the 56 rats were selected to participate in the experiment proper. The eight remaining were discarded for failure to meet specific pretraining criteria.

Apparatus

The apparatus consisted of a straight alley runway with a start box on one end and a goal box on the other. The runway and start box had a width of 15 cm. each while their respective lengths were 122 cm. and 30 cm. The goal box was 30 cm. long and 25 cm. wide. The overall length of the entire apparatus was 182 cm. The height of the apparatus was 13 cm. throughout except for the frames of the two guillotine doors which extended 18 cm. above the rest of the apparatus. These two doors divided the apparatus into the three different sections, i.e., start box, runway, and goal box. The guillotine doors were made of clear Plexiglas and could be raised and lowered in their aluminum frames by means of monofilament nylon lines. The wooden parts of the apparatus were painted a flat medium grey. The ceiling over the three sections consisted of three hinged covers of clear Plexiglas. The floor of the apparatus consisted of steel rods 6 mm. in diameter which were placed 13 mm. apart. This grid could be electrified in the start box and runway sections.

Raising the start box door caused current to flow into the grid. Current was supplied by a CJA Model 250 stimulator and connected to the stimulator was a Minarik Model 255 Grid Shock Scrambler which changed the polarity of the individual grids at the rate of five times per second.

Timing was achieved through the use of two Hunter photoelectric relays and two Hunter Klockcounters. The two photoelectric relays were placed just outside the start box and the goal box and were 114 cm. apart. Upon raising the start box door, a Klockcounter was activated which did not stop until the $\underline{S}$ intercepted the first relay just outside the start box. This Klockcounter gave a measure, the reciprocal of which is referred to as start speed. The $\underline{S}$'s interception of the first relay also started a second Klockcounter which did not stop until the second relay was broken. The reciprocal of this time is referred to as run speed. Lighting of the apparatus was by overhead fluorescent lights which were covered with translucent plastic to reduce shadows. A stainless steel water tray, the dimensions of which were 254 x 172 x 12 mm., was placed at the back of the goal box during all trials in which the $\underline{S}$s were water-deprived. Immediately in front of this tray was a 5 x 25 cm. wooden barrier which was used to prevent $\underline{S}$s from seeing the tray from the runway.

Procedure

Pretraining. All $\underline{S}$s were given preliminary training consisting

of 5 days of handling followed by 12 days of training to drink from the metal water tray. All pretraining was done in a room different from the one in which training was done. During the handling days, each rat was handled for 3 minutes. During the tray-drinking days, each animal was under 23-hr. water deprivation and was allowed 3 minutes' access to the tray of water. At the start of this 3 minute period, each rat was placed on top of a 102 by 64 cm. metal table which was painted the same color as the apparatus. A tray of water was set at one end of the table, and each S was placed facing it at a distance of approximately 30 cm. After the pretraining, 48 of the 56 rats which drank from the tray on all of the last three days were randomly divided into 4 groups of 12 each. This criterion was to reduce the likelihood of rats not drinking in the goal box and thereby not being reinforced for moving down the alley in response to thirst cues.

Training. On each trial the S was placed in the start box and delayed there for either 15, 20, 25, or 30 seconds. The particular delay time for any given trial was the same for all animals, and its value was determined from a table of random numbers. This delay period was used to prevent start speeds from being influenced by temporal conditioning. At the end of the delay period, the start box door was raised, and the S could proceed to the goal box. Once the S had entered the goal box, the goal box door was closed behind him, and he was allowed to remain there for 30 seconds. In addition

to being safe from shock, the goal box always contained a tray of water for all Ss which were water-deprived.

The training part of this experiment consisted of two separate stages which will be referred to as the acquisition phase and the transfer phase. The acquisition phase consisted of 5 trials per animal per day, on alternate days, for 16 days. Thus each S was given a total of 40 trials during the acquisition phase. The inter-trial interval during any one day's trials was approximately 10 minutes. During acquisition, Group 1 was trained under conditions of weak thirst and weak shock; Group 2, under weak thirst and strong shock; Group 3, under strong thirst and weak shock; and Group 4, under strong thirst and strong shock. These terms were operationally defined as follows: weak thirst was 10 hours' water-deprivation; strong thirst, 45 hours' water-deprivation. Weak shock was a grid current of 30 microamps; strong shock, 1.0 milliamp.

After the acquisition phase, a transfer phase was introduced in which each animal was again given 5 trials per day, on alternate days, for 16 days. In the transfer phase each of the 4 original groups was randomly divided into two subgroups of 6 rats each. The rats in each of these subgroups were continued on only one of their two previous motive conditions. For example, Group 1 which had been trained in the acquisition phase under conditions of both weak thirst and weak shock, was divided into Subgroup 1A and Subgroup 1B. Subgroup 1A was then continued on weak thirst only while Subgroup

1B was continued on weak shock only. Table 1 shows each group and its corresponding subgroups.

During both phases of training, all drives were relevant at all times. That is to say that all animals which were water-deprived always encountered a tray of water in the goal box. For those animals which were transferred to shock alone, the tray was removed from the goal box.

The first of the two specific hypotheses which this experiment tested was that when Ss which have been motivated by both appetitive (thirst) and aversive (shock) drives are later motivated by an appetitive drive alone, their performance will be inversely related to the strength of the aversive drive during their original training under both drives. That is, the higher the shock level during acquisition, the slower the performance during transfer. If this hypothesis is correct, then Subgroup 1A (weak thirst) should have a faster speed, i.e., show less suppressive effect, than Subgroup 2A (weak thirst) since during acquisition, 1A received weak shock while 2A received strong shock.

The second, related hypothesis was that when Ss which have been motivated by both appetitive and aversive drives are later motivated by an aversive drive alone, their performance will be inversely related to the strength of the appetitive drive during their original training under both drives. That is, the higher the thirst level during acquisition, the slower the performance during transfer.

If this hypothesis is correct, Subgroup 1B (weak shock) should be faster than Subgroup 3B (weak shock) since during acquisition, 1B was under weak thirst while 3B was under strong thirst. In a similar vein, Subgroup 2B should be faster than Subgroup 4B.

TABLE 1

Groups during Acquisition and their
Corresponding Subgroups during Transfer

Groups

1			2			3			4	
WT & WS			WT & SS			ST & WS			ST & SS	

Subgroups

1A	1B		2A	2B		3A	3B		4A	4B
WT	WS		WT	SS		ST	WS		ST	SS

III. RESULTS

The original time scores which were recorded to the nearest one-hundredth of a second were changed to speed scores by the conversion factor, 100/time. Of the five daily trials, the one with the median value was considered as being the most representative of that S for that day and was used in all statistical computations. In addition to the comparisons previously mentioned, the data were combined, and the following comparisons were also made: (1) 1A and 3A vs. 2A and 4A in which the two thirst levels were summed; (2) 1B and 2B vs. 3B and 4B in which the two shock levels were summed; and (3) 1A, 1B, 3A and 2B vs. 2A, 3B, 4A, and 4B in which both thirst levels and shock levels were summed.

During the experiment one S was eliminated because of illness, and the missing data for this S were generated by taking an unweighted average of the others in his subgroup in accordance with Winer (1962).

Tables 2 and 3 show start and run speeds for acquisition and transfer trials. Although the start speeds had a fairly regular pattern during acquisition, they became quite intertwined during transfer. An analysis of variance for all start speeds for the first three days of transfer yielded an F of 2.04 while an F of 2.25 is needed to be significant at the .05 level with 7 and 39 d.f. However Scheffe's Test for Multiple Comparisons (Edwards, 1964) which was used for all subgroup comparisons does not require a significant treatment mean square in order to be used. An analysis of variance for start speeds for the last three days of transfer gave an F of 4.60 which is significant at the .01 level. However none of the seven subgroup comparisons of start speeds was

TABLE 2

Start and Run Speeds for All Acquisition Trials

Groups	Start Speeds	Run Speeds
1	128.81	12.64
2	290.04	114.40
3	248.47	23.41
4	262.27	123.90

TABLE 3

Start and Run Speeds for Transfer Trials

Subgroups	Start Speeds		Run Speeds	
	first 3 days	last 3 days	all trials	last 3 days
1A	242.94	332.22	26.27	29.43
1B	149.33	165.72	17.83	20.00
2A	224.39	276.06	34.54	25.37
2B	341.88	387.83	96.48	90.87
3A	320.44	344.11	69.29	76.33
3B	215.11	191.28	13.42	13.75
4A	255.33	326.78	53.44	60.81
4B	283.50	386.39	100.92	94.99

significant at the .05 level for either the first three or the last three days of transfer. The values which were obtained for each sub-group comparison are listed in Table 4.

The run speeds during transfer seem more regular than the start speeds. An analysis of variance for all run speeds for all transfer trials gave an F of 16.67 while an analysis of variance for the last three days of transfer gave an F of 12.39. Both of these F values are significant at better than the .01 level. As in the case with start speeds however, none of the seven subgroup comparisons of run speeds was significant at the .05 level for either the last three days or for all transfer trials.

In addition to the subgroup comparisons which were of primary interest, an analysis of the four original groups during acquisition was also made. Table 5 gives the values for these comparisons. Note that the 1 vs. 2 comparison is significant for both start and run speeds, that the 1 vs. 3 and 2 vs. 4 comparisons are not significant for either start or run speeds, and the 3 vs. 4 comparison is significant only for run speeds. Ideally for the tentative conclusions which will be drawn from these data, the start speeds for the 3 vs. 4 comparison should also have been significant. Thus it appears definitely for running performance and suggestively for starting performance that the level of performance is totally independent of the strength of the appetitive drive. More will be said of this in the Discussion section.

TABLE 4

$\underline{A}$ Values from Scheffe's Test for Subgroup
Comparisons of Start and Run Speeds

Subgroup comparisons	Start Speeds		Run Speeds	
	first 3 days	last 3 days	all trials	last 3 days
1A vs. 2A	.93	8.52	1.31	4.45
1B vs. 3B	11.63	1.76	.37	10.55
3A vs. 4A	11.45	.81	4.83	65.05
2B vs. 4B	9.20	.01	.38	4.58
1A+3A vs. 2A+4A	9.45	7.29	.55	51.77
1B+2B vs. 3B+4B	.07	.78	.00	.61
1A+1B+3A+2B vs. 2A+3B+4A+4B	3.93	1.65	.27	31.83
	158.67	130.67	43.19	761.42

Note: for significance at the 5% level, the $\underline{A}$ values in each column must equal or exceed the underlined $\underline{A}$ value at the bottom of each column.

TABLE 5

$\underline{A}$ Values from Scheffe's Test for Group Comparisons
of Start and Run Speeds for All Acquisition Trials

Group comparisons	Start Speeds	Run Speeds
1 vs. 2	1,996.40	79,535.94
1 vs. 3	1,099.59	890.45
2 vs. 4	59.23	692.97
3 vs. 4	14.63	77,565.10

Note: for significance at the 5% level, each
$\underline{A}$ value must at least equal 1,842.84.

IV. DISCUSSION

As can be seen from Table 3, the start speeds during transfer are rather overlapping and confused. About all that can be said is that in general the start speeds correlate reasonably well with the run speeds and follow the same general order. That is, in both cases, the conditions strong shock, strong thirst, weak thirst, and weak shock produced a similar rank ordering of speeds.

The run speeds also shown in Table 3 present a much more orderly picture with relatively little overlap between subgroups. Unfortunately, in this case too the within-groups variability was so great as to obscure the between-groups variability. It is felt that one possible reason for the failure to achieve statistical significance for any of the transfer trials was the use of too few $\underline{Ss}$. However, in as much as the results missed reaching significance by such a large margin, a more likely explanation would seem to be that the original hypothesis is incorrect. More will be said of this after a discussion of the results of the acquisition phase.

The main finding of importance in this experiment is with regard to what happened in the acquisition phase where a very interesting relationship was noted. Namely, that while the strong and weak shock groups differed significantly from each other, the strong and weak thirst groups did not. That is, strong shock when paired with strong thirst did not differ from strong shock paired with weak thirst. Likewise, and far more surprisingly, weak shock paired with strong thirst did not differ from weak shock paired with weak thirst. Thus the only main effect that distinguished the groups was shock level.

Due to the design of this experiment the absolute effect of the appetitive drive on performance cannot be assessed. However it can be deduced that the level of the appetitive drive did not significantly affect performance. It might be argued that this is merely an artifact resulting from appetitive drive levels which did not differ enough from each other. However, as will be recalled, the two levels differed quite greatly from a mild 10 hours' water-deprivation to a very strong 45 hours' water-deprivation. Given these two rather extreme levels, it seems likely that the appetitive drive per se is having little or no effect. This inference is made on the basis of no difference between the two appetitive drive levels. That is, it seems reasonable to expect that if the appetitive drive is having an effect, the effect would be at least somewhat influenced by the level of the drive. Of course without single condition control groups, the validity of the above reasoning remains open to question.

Assuming it is true that thirst drive does not increment shock drive, this finding agrees with the results of Muenzinger & Fletcher (1936) who concluded that a combination of two drives results not in summation, but rather in an effect no stronger than that produced by the stronger drive alone. If this is indeed the case, then the problem remains to develop a reasonable explanation. First of all the lack of difference between strong shock and strong thirst vs. strong shock and weak thirst can probably be most parsimoniously explained as resulting from the fact that the strong level of shock was alone producing maximum

performance. It is obvious that if the level of a single drive is producing maximum performance then the addition of another drive can only either fail to affect or lower the performance level. The lack of difference between weak shock and strong thirst vs. weak shock and weak thirst cannot be accounted for so easily however. We know that these low-shock animals are not running as fast as they can. We also know that in the transfer phase after the weak shock was dropped, the strong thirst group ran significantly faster than the weak thirst group. Why then did they fail to do so when both were combined with weak shock? The probable answer seems to be that the shock was acting as a suppressor variable reducing running speeds. In fact its action seems to have virtually canceled the effect of the thirst drive since both animals under high and low thirst ran at the same speed. From observation, what seemed to be happening was that the weak shock was interfering with any fast running response. That is, the animals would start to move down the runway at a very slow pace, stopping frequently, and even backtracking after receiving shock with every extension of a forepaw. Thus shock seemed to be acting as a punisher of rapid forward movement while at the same time providing the impetus for approach to the goal box.

It is also possible that shock may be obscuring other drive stimuli. When being shocked, a rat may well be less sensitive to its internal states, e.g., thirst, than under normal circumstances. For example, a drinking rat upon being shocked will at least momentarily cease

drinking. These disruptive properties of shock may derive from its novelty and/or aversiveness. The relatively greater novelty of shock than thirst is due to several factors. First of all, the rats had experienced thirst but never shock before this experiment. Second, shock is a more novel stimulus since it is associated only with the cues of the runway and is not with the rat at all times as are thirst stimuli. This is likewise true for the aversive qualities of shock in comparison with those of thirst. Shock cues are present only for the few minutes in the runway while thirst cues are present many hours per day regardless of where the rat is.

Another factor which may be of importance in the weak shock conditions is the delay of reinforcement for beginning to move down the runway. That is, there is a long duration between the time when a rat first receives shock and begins to slowly move down the runway, and the termination of shock with entering the goal box. Thus it may be difficult for the animals to learn to move down the runway to safety because of the relatively long period during which their responses go unreinforced.

In summary it appears that the appetitive drive was having little or no effect in the acquisition phase of the experiment. Assuming that this was indeed the case then it is quite understandable why there were no significant differences in the transfer phase. The basic hypothesis of this experiment presupposes that both drives will have an effect in the acquisition phase, and that their relationship will determine what will happen in the transfer phase.

Without both drives being effective in acquisition, the predicted effects in transfer cannot be expected. Thus it seems probable that the original hypothesis is either incorrect or at least not as broadly applicable as initially assumed.

V. SUMMARY

Many studies in psychology have investigated the immediate effects
on performance of a combination of drives. However, very few have
considered the subsequent effects on performance of drive combinations.
It was for the purpose of assessing certain aspects of these successive
effects that this study was done. Combining and extending the results
of previous research studies suggested the possibility that when
subjects which have been motivated by two drives are later motivated
by only one of these drives, their performance is inversely related
to the strength of the drive which was discontinued.

In this study two levels of thirst (10 and 45 hours' water-deprivation)
were combined with two levels of shock-escape drive (.03 and 1.0
milliamp) to form four groups with 12 rats per group. These animals
were given 40 trials (acquisition) in a straight alley which was
electrified in its start box and runway sections and which contained
a tray of water in its goal box section. After acquisition, each of
the four groups was randomly divided into two subgroups of 6 rats
each, and each subgroup was given an additional 40 trials under only
one of its two previous drive conditions (transfer). All drives were
relevant at all times.

Starting and running speeds were analyzed for both acquisition
and transfer trials. Results from the transfer trials failed to
reach statistical significance by such a large margin that the
validity of the original hypothesis is seriously questioned. Sur-
prising results from the acquisition phase of the experiment suggest

that the appetitive drive was having no effect on performance during

acquisition. Reasons why shock may have been acting as a suppressor

variable were discussed.

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