DRIVE CONDITIONING AS A FACTOR IN LATENT LEARNING[1]

PAUL E. MEEHL AND KENNETH MACCORQUODALE

University of Minnesota

In 1929 Blodgett reported a now-classic experiment in which rats which had been running a maze without food reward exhibited a sudden drop in errors on the day following a single rewarded run. We do not propose here to discuss the experimental reality of this "Blodgett effect," which has not as yet been shown to be consistently reproducible (Blodgett, 1946; Meehl & MacCorquodale, 1951; Reynolds, 1945; Tolman & Honzik, 1930), nor the theoretical and statistical controversies involved in its inter-pretation, which have been treated at length by Kendler (1952), Maltzman (1952) and Thistlethwaite (1951, 1952) in recent papers. Assuming for present purposes that the effect *does* occur, we wish to examine its theoretical implications from another angle. Critics of S–R-reinforcement theory from Tolman on (1932, p. 343; 1948, p. 194) have taken it for granted that the *feeding in the goal box* is what brings about the subsequent sudden appearance of an error decrement. But actually the experiment does not establish this, since no control feeding outside the goal box or temporally separated from a maze run was employed. From the human observer's viewpoint (especially if he has cognitive-map leanings) it is quite natural to assume that if a feeding *in the goal* and *following a run* yields the Blodgett effect, this particular spatio-temporal locus is what does the business. But such an assumption clearly requires scrutiny.

This is the more so because there is an intriguing S–R-reinforcement possibility which presents itself as soon as the above issue is once raised. It is admitted on all sides that *some* decline in errors is shown by the nonrewarded rats during the "latent phase." We need not consider here what rewards may be operative to produce this already *manifest* learning (but cf. MacCorquodale & Meehl, 1951). The sticker for a rein-forcement theorist, at least as we perceive it, hinges on the quantitative question, "Why such a drop from one reinforcement at this level of the learning curve?" Now one of the ways to get sudden shifts in *performance* without equally sudden changes in *habit* (or cognitive!) variables, according to S–R-reinforcement theory, is to alter *motivation*.

Discussions of the Blodgett effect tend to assume that the place to look for the explanation is in the operation of reinforcement and resulting habit strength. But if in this design there is inherent some mechanism that provides for a shift in the rat's degree of hunger, might this not be a better place to look? If $_sE_R$ is a multiplicative function of $_sH_R$ and $f(D)$, increasing either factor will increase $_sE_R$.

Human introspection suggests that the "subjective state" of hunger, for a given interval of deprivation, can be manipulated by exteroceptive cues. Presumably Hull's Corollary i of Postulate III in the 1949 set, "Secondary Motivation" (Hull, 1950, p. 175), is intended to cover this kind of *environmental control over drive level itself*. There is independent evidence (Hilgard & Marquis, 1940, p. 33) that some of the presumed "components of being hungry," such as stomach contractions, salivation, damped ingestive responses, and even blood-sugar level can be brought under some degree of exteroceptive control. Thinking along these lines, we were struck by the following hypothesis: During the latent phase, differential habit strengths are accumulating in favor of the "correct" choices (as the data show). At the end of the first rewarded run, the rat feeds in the goal box and by the above corollary acquires a conditioned hunger drive (or, more precisely, his hunger drive, which during the latent runs has been based upon mere deprivation, is now strengthened by the new exteroceptive conditioning). On the following day's run, this conditioning generalizes to the similar (and partially over-lapping) stimulus complex of being "in the maze," so that the rat, although under the same deprivation as on previous days, is now "hungrier" than he was on these days. Hence, we have an augmented drive factor which, according to Hullian theory, will multiply by the (also augmented!) habit strengths already favoring the correct path and hence produce the Blodgett drop.

Admittedly this is a touchy hypothesis to test, and we must emphasize that the design which follows is not presented as an *experimentum crucis* to clinch any such argument. As usual in such "derivations," the hypothesis does not actually quantify the parameters but it does require that certain rather complex relations obtain among their magnitudes. We have tried to test just *one* implication of such a hypothesis, and this test can only be added to the other numerous lines of evidence and theory needed to explicate Blodgett's experiment. However, the prediction confirmed is somewhat paradoxical and its rather

bizarre character perhaps makes its success more probative than would ordinarily be the case.

For if the above hypothesis were correct, one should be able to produce the drop in errors by a feeding *not* in the goal box and *not* at the conclusion of a run. In fact, a feeding experience administered in a sufficiently "maze-like situation" should bring about the desired drive conditioning. (We are, of course, *not* talking here of "prefeeding," i.e., just before a day's run, as a facilitator.) Accordingly, we determined to substitute a feeding experience in a maze-like but extramaze box for the single rewarded run introduced by Blodgett, meanwhile avoiding the possibility of a directional or locational learning by actively opposing any such factor through the arrangement of apparatus.

METHOD

Subjects.—Thirty male albino rats, approximately 90 days old and experimentally naive, were used. These were subsequently subdivided into two matched groups of 15 rats each, as described below.

Apparatus.—We used a replica of the six-unit multiple-**T** Blodgett maze; unlike his, ours had a permanent floor. The maze was placed on the floor, diagonally across the experimental room, which was square, windowless, otherwise unfurnished, and quiet. The illumination came from a 7½-w. overhead light, placed symmetrically with respect to the maze and providing a uniform brightness of less than ½ ft.-candles at maze level.

The extra-maze box was a 2-ft. long section of alley identical in composition, color (black), and in height and width dimensions with the alleys of the maze. This was placed on a stand in the experimental room, so that its floor was 4 ft. above the level of the maze floor, about one yard in front of the starting box of the maze in the opposite direction from the goal box. The long axis of this box was at right angles to the major (start-to-goal) axis of the maze. This is the box in which half the rats were to be fed after a series of nonrewarded maze runs.

Procedure.—Test breaking: Since the maze trials in this experiment were to be run under conditions of food deprivation but without primary food reinforcement in the maze, we took special precautions to assure that emotionality in the experimental situation would be minimized, and that a feeding rhythm would be established, during the test-breaking phase. This lasted seven days. Throughout this period each rat was handled and carried about for 1½ min. daily. Each rat was given about 10 gm. of wet mash daily at the hour at which he would be fed during the experimental sessions proper. Feeding was done in special feeding cages of different construction and dimensions from the home cages. On the fourth, fifth, and sixth test-breaking days, the rats

were placed, in squads of five, in a tunnel-type straightaway for 20 min. The long axis of the straightaway was at right angles to the long (start-to-goal) axis of the maze. The point of entry into the straightaway was randomly varied; the point of removal was always from the middle two-thirds of the alley. The straightaway had no goal boxes and never contained food. From the straightaway the animals were removed to individual "detention" cages, differing markedly from both home and feeding cages, for 20 min., thence to the feeding cages where food was withheld for 40 more minutes, e.g., for one hour after removal from the straightaway. The purpose of the detention cages was to reduce, or at least temporally delay, the secondary reinforcing effects of the feeding cages. On the seventh test-breaking night the straightaway was not used, but instead the rats were placed singly in the extra-maze box (as described above) for 3 min., then removed to the detention and feeding cages as before.

Maze running: All rats were treated identically during the first five days. One maze trial was given daily, under 22½-hr. food deprivation. Immediately preceding his day's run, each rat was placed for 30 sec. in the extra-maze box, from which he was removed directly to the starting box of the maze. There was no food in the goal box of the maze at any time. Retracing was prevented by swinging doors. The rats were detained in the goal box 1 min. following the run. Then, as during the test-breaking period, they were removed to the detention cages for 20 min., thence to the feeding cages, where food was withheld for at least another 40 min. Records were kept of running times and of calibrated errors; an error score of 1 was recorded if the rat placed his head and forepaws but not his hind feet into the cul; a 2 was recorded if his body, including the hind feet, entered the cul but his nose did not pass the point marked 3½ in. from the end of the cul; a 3 was recorded if his nose passed this mark. According to this system, only cul penetrations to the depth scored 2 or 3 would have been counted by Blodgett as errors; henceforth such errors will be called Blodgett errors. After the fifth night's runs, two pairwise matched groups of 15 rats each were formed. The matching was on the basis of several error criteria: total number of Blodgett errors over all five days; summed weighted errors over all five days; total Blodgett errors on Day 5; summed weighted errors on Day 5. The closeness of the matching may be inferred from the failure of the curves in Fig. 1 and 2 to diverge markedly over the first five trials, and from their convergence on Trial 5.

On the sixth night, neither group was run in the maze. The rats were handled in the usual order, but those which were assigned to the "extra-maze fed" group were placed in the extra-maze box where, for the first time, they found a cup of wet mash, which they were permitted to eat for 2 min. The food cup was located about two-thirds of the alley length from the end at which the rats were inserted. The "not-fed" animals were also placed in the extra-maze box for 2 min., with

no food present. All rats were removed from the extra-maze box to the detention and feeding cages as before. Each extra-maze-fed rat was ultimately given the same food cup he had eaten from in the extra-maze box, to ensure that this group did not eat more than the nonfed group. If, then, the drive-conditioning mechanism does occur as a result of eating in a similar situation, its effects should be observable in the greater error reduction of the extra-maze fed group, as compared with the nonfed group, on the subsequent run.

The sixth, or test, trial was run the following night. As before, rats were placed for 30 sec. in the extra-maze box (no food or food cup being present), and then performed one unreinforced maze run. Errors and time were recorded as before.

RESULTS

Since there was a definite antecedent expectation that the box-fed rats would do better on the test run than the nonfed, it seems appropriate to employ one-tailed significance tests throughout (Jones, 1952). Figure 1 shows the performance of the two groups in terms of "Blodgett errors" as defined above. The *t* test for matched groups on the test run is 2.01 ($.02 < p < .05$). For eight of the matched pairs the fed were superior to the nonfed, while for two pairs the reverse obtained. The other five pairs were equal. It should be noted that 28 of the 30 Blodgett scores lie in the narrow range of scores from 1 to 3, so this test is perhaps not very sensitive.
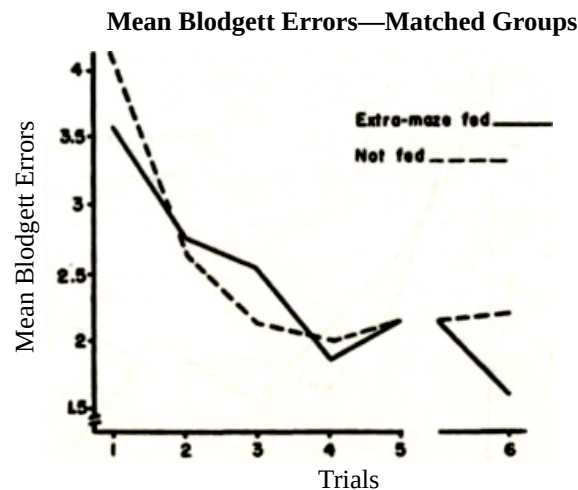

FIG. 1. Performance of two groups in terms of "Blodgett errors"

A more sensitive measure of actual performance is shown in Fig. 2, plotting the daily "weighted errors" as defined above. Here also the *t* test is 2.01 (.02 < *p* < .05). Inspection of the distributions shows that 73% of the nonfed exceed the median error score of the fed, and 73% of the latter fall below the former's median. One-third of the nonfed made more errors than any of the fed. Of the 15 matched pairs, 10 show a difference score favoring the fed rat, 1 pair is equal, and 4 show the nonfed superior. Examining these discrepancies by means of Wilcoxon's nonparametric matched pairs signed rank test (Moses, 1952, p. 126) we find a *T* of 27.5 as the sum of ranks with less frequent sign, contrasted with a chance expectancy of 60 (*p* < .05; Wilcoxon, 1947, p. 120). The median test, which does not take advantage of the experimental matching, yields a *p* between .02 and .05 (Moses, 1952, p. 125).
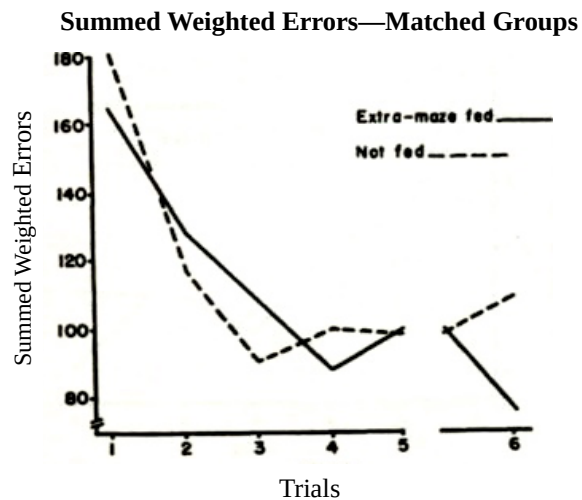

FIG. 2. "Weighted errors" of two groups

An analysis of the individual rats' *gains* in weighted errors between the last prefeeding run and the test run was almost exactly at *p* = .05 (*t* = 1.73, 14 *df*) for Blodgett errors, and between the 3 and 4% levels of confidence for weighted errors (*t* = 1.996). Wilcoxon's test again yields a sum of 27.5 (*p* < .05).
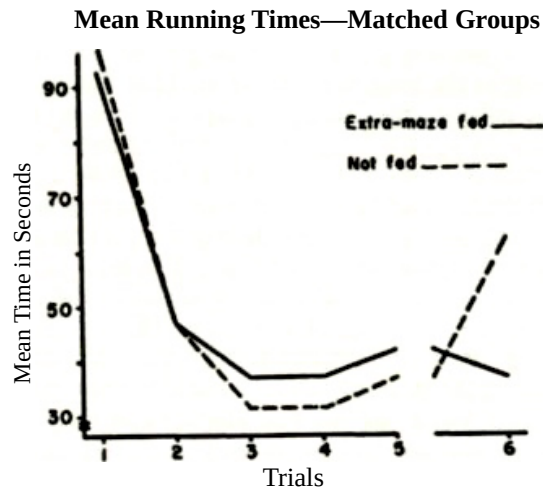
Mean Running Times—Matched Groups

FIG. 3. Effect of extra-maze feeding upon
running time

The effect of the extra-maze feeding upon running times [Fig. 3] was somewhat more striking. Seventy-three per cent of the nonfed exceed the median running time of the fed, and all of the fed fall below the nonfed median. The mean running time for the two groups differed by 25.2 sec. (36.1 for the fed, 61.3 for the nonfed). A t test (matched formula) yields $t = 3.62$ (p $<$ .01). Wilcoxon's test shows a $T = 10$ instead of the theoretical 60, which is at the 1% level of confidence. It seems appropriate to conclude that the extra-maze feeding exerted a significant error-reducing and speeding-up effect upon maze performance during the next day's run.

SUMMARY AND CONCLUSIONS

Hungry rats were run in the six-unit Blodgett maze one trial per day for five days, no food reward being given. During this period they showed a reduction in errors which had leveled off by the fifth day. Two groups were then formed by matching individual rats by pairs in terms of several measures of their performances to that time. On the following day none of the subjects ran the maze, but were placed in a familiar mazelike box located several feet above the maze and behind the maze end opposite the goal box. One group fed in this box on that day, the other did not. On the following day's run the fed rats were significantly superior to the nonfed in both time and errors. The results were those

predicted from a hypothesis that the Blodgett effect is at least partly due to conditioning of hunger drive to the exteroceptive stimuli of the maze situation.

(Received July 10, 1952)

REFERENCES

Blodgett, H. C. (1929). The effect of the introduction of reward upon the maze performance of rats. *University of California Publications in Psychology, 4*, 113-134.

Blodgett, H. C. (1946). Reynolds' repetition of Blodgett's experiment on latent learning. *Journal of Experimental Psychology, 36*, 184-186.

Hilgard, E. R., & Marquis, D. G. (1940). *Conditioning and learning.* New York: Appleton-Century.

Hull, C. L. (1950). Behavior postulates and corollaries—1949. *Psychological Review, 57*, 173-180.

Jones, L. V. (1952). Tests of hypotheses: One-sided vs. two-sided alternatives. *Psychological Bulletin, 49*, 43-46.

Kendler, H. H. (1952). Some comments on Thistlethwaite's perception of latent learning. *Psychological Bulletin, 49*, 47-51.

MacCorquodale, K., & Meehl, P. E. (1951). On the elimination of cut entries without obvious reinforcement. *Journal of Comparative & Physiological Psychology, 44,* 367-371.

Maltzman, I. (1952). The Blodgett and Haney types of latent learning experiment: reply to Thistlethwaite. *Psychological Bulletin, 49,* 52-60.

Meehl, P. E., & MacCorquodale, K. (1951). A failure to find the Blodgett effect, and some secondary observations on drive conditioning. *Journal of Comparative & Physiological Psychology, 44,* 178-183.

Moses, L. E. (1952). Non-parametric statistics for psychological research. *Psychological Bulletin, 49,* 122-143.

Reynolds, B. (1945). A repetition of the Blodgett experiment on latent learning. *Journal of Experimental Psychology, 35*, 504-516.

Thistlethwaite, D. (1951). A critical review of latent learning and related experiments. *Psychological Bulletin, 48,* 97-129.

Thistlethwaite, D. (1952). Reply to Kendler and Maltzman. *Psychological Bulletin, 49*, 61-71.

Tolman, E. C. (1932). *Purposive behavior in animals and men.* New York: Century.

Tolman, E. C. (1948). Cognitive maps in rats and men. *Psychological Review, 55*, 189-208.

Tolman, E. C., & Honzik, H. C. (1930). Introduction and removal of reward, and maze performance of rats. *University of California Publications in Psychology, 4*, 257-275.

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics Bulletin, 1*, 80-82.

Wilcoxon, F. (1947). Probability tables for individual comparison by ranking methods. *Biometrics, 3*, 119-122.