Simultaneous shifts in reward magnitude and level of food deprivation

ELIZABETH D. CAPALDI
Purdue University, Lafayette, Ind. 47907

Rats were employed in a 2 by 2 factorial design varying deprivation level (11 vs 20 g of food per day) and reward magnitude (1 vs 10 pellets) in Phase 1. In Phase 2, all groups were run to 10 pellets under low deprivation. Both Phase 1 deprivation level and Phase 1 reward magnitude exerted a significant effect on running speed in Phase 2. More importantly, the interaction of these two variables was not significant. The effect of Phase 1 reward magnitude decreased over the rewarded trials of Phase 2, while the effect of Phase 1 deprivation level did not. However, in a subsequent extinction phase, the effects of Phase 1 deprivation level disappeared.

It has been reported that animals shifted from high deprivation to low (e.g., of food) subsequently run faster to reward than do animals trained and tested under a low level of deprivation (O'Kelly & Heyer, 1948; Timberlake, 1967; Zaretsky, 1966). Moreover, this effect persists for a considerable number of trials. It has also been reported (Gragg & Black, 1967) that running speed is slower when deprivation level is shifted from high to low and the reward magnitude is changed (either increased or decreased) rather than unchanged. In the Gragg and Black investigation, all groups were shifted from a high to a low level of deprivation. A possible interpretation of the Gragg and Black finding is that the effects of prior deprivation may be less persistent when reward magnitude is shifted. The present experiment was designed to determine if the effects of prior deprivation are less persistent when reward magnitude is shifted. The present investigation employed groups trained under low deprivation in Phases 1 and 2 as well as groups shifted from high deprivation in Phase 1 to low deprivation in Phase 2. Within each deprivation condition, reward magnitude was either changed or unchanged between Phases 1 and 2. The purpose of the investigation, then, was to determine if the effects of previous deprivation conditions on present performance are greater when the reward magnitude is unchanged rather than changed.

SUBJECTS

The Ss were 40 naive male rats, approximately 90 days old when received from the Holtzman Co., Madison, Wisconsin, randomly assigned to four groups.

APPARATUS

The apparatus consisted of a runway painted flat gray throughout, 57 in. long, 3½ in. wide, with 4-in.-high sides and covered with ½-in. hardware cloth. The startbox was

separated from the runway by a metal door which E dropped by pushing a button. Dropping the door started the first .01-sec clock. Clock 1 was stopped (start time) and Clock 2 started when S interrupted a photobeam, 12 in. from the door. Clock 2 was stopped (run time) and Clock 3 started when S broke the second photobeam, located 17 in. from the first. Interruption of the third photobeam stopped Clock 3 (goal time). The third photobeam was 12 in. beyond the second photobeam and 3 in. in front of a gray block of wood with a 1¼-in.-diam and ¾-in.-deep hole where the pellets were placed. A manually lowered guillotine door, 13½ in. from the rear of the goal compartment, served to confine S to the goal area.

PROCEDURE

The study was run by two Es, each running half the Ss in each group. There were three phases in the experiment. In Phase 1, the design was a 2 by 2 factorial combining two levels of deprivation (high, 11 g of food per day, vs low, 20 g of food per day) and two magnitudes of reward [1 (S) vs 10 (L) .045-g Noyes pellets]. In Phases 2 and 3, all groups were treated identically. In Phase 2, all groups were run to the same reward magnitude (10 pellets) under the same deprivation level (low, 20 g of food per day). Phase 2 deprivation (low) was maintained in Phase 3 when all groups were extinguished. The groups are designated by the deprivation level and reward magnitude received in Phase 1, e.g., Group S-low received small reward under a low level of deprivation in Phase 1. On Day 1, the animals were assigned randomly to four groups, and the deprivation schedule was begun. Animals were handled in groups of five for 10 min on Days 8-10 and were given .045-g pellets in their home cages 15 min after handling. Groups S-high and S-low received 1 pellet in their home cages and Groups L-high and L-low

received 10 pellets. This amount was subtracted from the daily ration, as was the amount of reinforcement received in acquisition each day. On Day 11, the animals explored the alley in groups of five for 5 min, with the photobeams operative, all doors open, and no food in the goalbox. On Day 12, acquisition began. Each animal received one rewarded trial on each of the first 2 days of acquisition, two rewarded trials on the 3rd day of acquisition, and four rewarded trials on each of the next 9 days. There were thus 40 trials in Phase 1. On all rewarded trials in the study, animals were removed from the goalbox immediately after they consumed the reinforcement. At the conclusion of Phase 1, Groups S-high and L-high were fed ad lib until the average weight of these groups was equivalent to that of Groups S-low and L-low. This took 10 days. Throughout this period, Groups S-low and L-low continued to be fed 20 g per day. When the average weights of all groups were equivalent, all groups were then fed 20 g per day for 4 days. Phase 2 was then begun (14 days after Phase 1 had ended). In Phase 2, then, all animals were under a low level of deprivation. Phase 2 lasted 11 days (four trials per day), every trial for every animal being rewarded with 10 pellets. All animals then received 6 days of extinction (four trials per day). The nonreinforced confinement duration in extinction was 20 sec. In extinction, the animal was given 60 sec to traverse each alley section, at which point he was guided gently to the next alley section, and 60 sec was recorded for the untraversed section. Throughout the experiment, animals were run randomly within squads of four composed of one animal from each group, producing an intertrial interval of about 5 min. A squad of animals was fed its daily ration minus any food consumed in the goalbox at least 15 min after their daily trials. Throughout pretraining and experimental training, the animals were weighed every other day. During the course of the experiment, one animal died in Group S-low and its data were discarded.

RESULTS

All times were converted to speeds (1/sec) and a 2 by 2 by 2 factorial between-within analysis, including Phase 1 deprivation level, Phase 1 reward magnitude, and E as factors, was done on speeds in each of Phase 1, Phase 2, and extinction. Results in each alley section were substantially the same, and thus only results for the run section are presented here, the cases where results for the start and goal were different being noted. Differences due to E were not

significant in any analysis, nor was any interaction involving E significant, and thus this variable is not mentioned further. In Phase 1, both deprivation level and reward magnitude exerted a significant effect on running speed, the higher level of deprivation and the larger reward magnitude producing faster running (deprivation level, $F = 50.35$, $df = 1/31$, $p < .001$; reward magnitude, $F = 51.45$, $df = 1/31$, $p < .001$). The interaction of deprivation level and reward magnitude was not significant in the run section ($F < 1$) but was significant in the start ($F = 9.63$, $df = 1/31$, $p < .01$) and goal ($F = 8.16$, $df = 1/31$, $p < .01$), where it was due to slow running on the part of Group S-low. Mean running speed for each group on the last day of Phase 1 and on each day of Phase 2, when all groups were run to large reward under a low level of deprivation, are presented in Fig. 1. As may be seen in Fig. 1, deprivation level and reward magnitude received in Phase 1 influenced Phase 2 performance. The higher the deprivation level in Phase 1 and the larger the reward magnitude in Phase 1, the faster the running in

Phase 2. Both of these effects were significant (deprivation level, $F = 6.08$, $df = 1/31$, $p < .02$; reward magnitude, $F = 4.38$, $df = 1/31$, $p < .05$). The interaction of Phase 1 deprivation level and Phase 1 reward magnitude was not significant ($F < 1$), indicating that the effect of Phase 1 deprivation level on Phase 2 performance was not greater if reward magnitude was unchanged. To attribute differences due to Phase 1 deprivation level in Phase 2 to Phase 1 deprivation level, it is, of course, necessary to demonstrate that deprivation level was equated at low in Phase 2. If weight loss is accepted as a measure of deprivation level (see Bolles, 1967), then deprivation level was different in Phase 1 and was equated in Phase 2. On the last day of Phase 1, for example, the mean weight of the high-deprivation animals was 312.8 g while the mean weight of the low-deprivation animals was 391.6 g ($F = 256.87$, $df = 1/31$, $p < .001$). On the first day of Phase 2, the mean weight of the high-deprivation animals was 410.6 g, while the mean weight of the low-deprivation animals was 403.8 g ($F = 1.91$, $df = 1/31$, $p > .05$). The effects of Phase 1 magnitude of

reward on Phase 2 performance decreased over days ($F = 3.44$, $df = 10/310$, $p < .001$), but the effects of Phase 1 deprivation level on Phase 2 performance did not ($F < 1$). In the run section on the last day of Phase 2, the effect of Phase 1 reward magnitude was not significant ($F < 1$), while the effect of Phase 1 deprivation level was significant ($F = 4.14$, $df = 1/31$, $p < .05$). In the start and goal, neither of these effects was significant in the last day of Phase 2. In extinction, however, the effect of Phase 1 deprivation level disappeared. Differences due to Phase 1 deprivation level were not significant on Day 1 of extinction ($F = 1.76$, $df = 1/31$, $p > .05$) or over extinction days ($F < 1$). In extinction, the only significant effect was that due to days in the start and run (run, $F = 61.72$, $df = 5/155$, $p < .001$). In the goal, the interaction of magnitude of reward received in Phase 1 with days was also significant ($F = 4.94$, $df = 5/155$, $p < .001$), groups which received small reward in Phase 1 decreasing in speed at a slower rate than groups which received large reward in Phase 1. This result has been obtained previously when employing a high level of deprivation throughout training (Capaldi, 1970).

DISCUSSION

In the present investigation, as in previous investigations (O'Kelly & Heyer, 1948; Timberlake, 1967; Zaretsky, 1966), animals previously trained under a high level of deprivation ran faster than animals previously trained under a low level of deprivation. As suggested by others (e.g., Zaretsky, 1966), this result could be taken to suggest the important conclusion that deprivation affects learning in some manner, rather than exerting its effects merely on performance. It was also found here, as reported by Gragg and Black (1967), that a group receiving a shift in reward magnitude as well as a shift in deprivation level (Group S-high) ran more slowly than a group receiving only a shift in deprivation level (Group L-high). The slower running of Group S-high in the present investigation did not reflect lesser persistence of the effects of previous deprivation level for this group. That is, the difference between Groups S-high and S-low in Phase 2 was no smaller than that between Groups L-high and L-low. Thus, the effect of previous deprivation level on present performance was not smaller if reward was changed rather than unchanged. However, the effect of Phase 1 deprivation level disappeared in extinction. Of course, extinction here followed Phase 2, and thus, the

Fig. 1. Mean run speed for each group on the last day of Phase 1 and each day of Phase 2.

effects of Phase 1 deprivation level may have disappeared even if rewarded trials had continued. Comparison of the results of previous investigations indicates, however, that the effects of previous deprivation level on performance in a test phase when deprivation level is equated at low are relatively small and transitory if extinction is employed as a test phase (Barry, 1958; Campbell & Kraeling, 1954; Lewis & Cotton, 1957) but are relatively large and persistent if a rewarded test phase is employed (O'Kelly & Heyer, 1948; Timberlake, 1967; Zaretsky, 1966). It is possible, then, that the effects of previous deprivation level will persist in a test phase under low deprivation if reward is given, whether or not the reward is a new one, but will disappear quickly if extinction is given. On the other hand, if extinction is viewed as a large change in reward magnitude, it is possible that the effects of previous deprivation level will persist in a test phase under low deprivation if reward is unchanged or changed by a small amount, but not if reward magnitude is changed by a large amount. This latter view would imply that the effects of Phase 1 deprivation level would have been smaller in the present investigation when reward magnitude was changed rather than unchanged if a larger shift in reward magnitude had been employed.

The variations employed in the present investigation seem relevant to another issue as well. Typically, in the runway no positive contrast effect is obtained (e.g., Schrier, 1967). That is, a group shifted from small to large reward does not usually run faster than a group which receives large reward throughout training. It has been suggested that the lack of a positive contrast effect may possibly be attributed to a ceiling effect (Bower, 1961). This view implies that if the large-reward control group is performing at a submaximum level, a positive contrast effect would be obtained. In the present investigation, Group L-low was performing below maximum level in Phase 2, as evidenced by its slow speed relative to Group L-high in Phase 2, and Group L-high was also performing below maximum level in Phase 2, as this group ran more slowly in Phase 2 than it had in Phase 1. Yet no positive contrast effects were obtained in the present investigation. Thus, the present results favor views which suggest that a positive contrast effect should not occur (e.g., Amsel, 1962; Capaldi & Lynch, 1967) and do not support the ceiling effect hypothesis. Shanab & Ferrell (1970) employed groups analogous to the present Groups S-high and L-high and

obtained a positive contrast effect. However, Shanab and Ferrell employed a modified Lashley Type III maze rather than a straight alley. The difference between Shanab and Ferrell's results and the present results is probably attributable to this difference in procedure.

REFERENCES

- AMSEL, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. *Psychological Review*, 1962, 69, 306-323.
- BARRY, H. Effects of strength of drive on learning and on extinction. *Journal of Experimental Psychology*, 1958, 55, 473-481.
- BOLLES, R. C. *Theory of motivation*. New York: Harper & Row, 1967.
- BOWER, G. H. A contrast effect in differential conditioning. *Journal of Experimental Psychology*, 1961, 62, 196-199.
- CAMPBELL, B. A., & KRAELING, D. Response strength as a function of drive level during training and extinction. *Journal of Comparative & Physiological Psychology*, 1954, 47, 101-103.
- CAPALDI, E. D. Effect of an initial reward magnitude on subsequent resistance to extinction. *Journal of Experimental Psychology*, 1970, 86, 283-287.
- CAPALDI, E. J., & LYNCH, D. Repeated shifts in reward magnitude: Evidence in favor of an associational and absolute (noncontextual) interpretation. *Journal of Experimental Psychology*, 1967, 75, 226-235.
- GRAGG, L., & BLACK, R. W. Runway performance following shifts in drive and reward magnitude. *Psychonomic Science*, 1967, 8, 177-178.
- LEWIS, D. J., & COTTON, J. W. Learning and performance as a function of drive level during acquisition and extinction. *Journal of Comparative & Physiological Psychology*, 1957, 50, 189-194.
- O'KELLY, L. I., & HEYER, A. W. Studies in response motivation and retention: I. Retention of a simple habit. *Journal of Comparative & Physiological Psychology*, 1948, 41, 466-478.
- SHANAB, M. E., & FERRELL, H. J. Positive contrast obtained in the Lashley maze under different drive conditions. *Psychonomic Science*, 1970, 20, 31-32.
- SCHRIER, A. M. Effects of an upward shift in amount of reinforcer on runway performance of rats. *Journal of Comparative & Physiological Psychology*, 1967, 64, 490-492.
- TIMBERLAKE, W. Straight alley acquisition drive and ad lib test performance. *Psychonomic Science*, 1967, 9, 585-586.
- ZARETSKY, H. H. Learning and performance in the runway as a function of the shift in drive and incentive. *Journal of Comparative & Physiological Psychology*, 1966, 62, 218-222.

Extraacquisitional factors in extinction: The effect of feeding activities of neighboring rats*

PAUL T. P. WONG and KENNETH L. TRAUPMANN†
University of Texas at Austin, Austin, Tex. 78712

Following asymptotic extinction training, additional nonrewarded trials produced an increase in running speed. The rate of this response increment was negatively related to the time elapsed since neighboring rats had been fed. Further, the increment was obtained only in the start and run segments of the alley and not in the goalbox.

While it has been firmly established that a number of acquisitional variables, such as the magnitude or schedule of reward, affect extinction

performance, the effect of extraacquisitional variables on extinction has received little attention. These extraacquisitional variables may be either historical or concurrent. Examples of historical extraacquisitional variables that might be relevant are early experiences such as handling, feeding frustration during the preweaning period, or any "incidental" learning prior to

*The research was supported by NSF Grant GB-14990X awarded to Abram Amsel.

†Requests for reprints should be addressed to Paul T. P. Wong, Department of Psychology, University of Texas at Austin, Tex. 78712.