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Effects of varying sucrose reinforcers and amobarbital sodium on positive contrast in rats

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The effect of quantity and quality of reinforcement on performance change following a shift to uniform high reward was studied in four groups of rats. Twenty or 200 licks of a 5% or 20% sucrose solution constituted the four incentive conditions. Two additional subject groups were run in the high (20%-200 licks) and low (5%-20 licks) reward conditions to determine how amobarbital sodium, an emotional depressant, influences incentive shift performance. All six groups received 60 preshift runway trials (6/day), followed by 30 high reward trials. Twenty-four extinction trials contrasted drugged and normal performance relating to high and low reward. Postshift positive contrast appeared in all nondrugged groups. An emotional base for positive contrast is considered.

When the magnitude of a food reward used to reinforce adient behavior in the runway is suddenly greatly increased, the subsequent level of performance may rise above that established by a nonshifted control group. This enhanced performance, called the "elation effect" by Crespi (1942) and the "positive contrast effect" (PCE) by Zeaman (1949), has proven more difficult to replicate than the "depression" or "negative contrast" effect following a downshift in reward magnitude (DiLollo & Lumsden, 1962; Schrier, 1967; Spence, 1956).

Successful demonstrations of positive contrast have emerged in those studies in which the subject has been given some prior experience with the high reward condition, either during pretraining or acquisition training (Benefield, Oscós, & Ehrenfreund, 1974; Calef, 1972; Wagner & Thomas, 1966; Zeaman, 1949), with the exception of the Capaldi and Lynch (1968) study. For Crespi's subjects the incentive increment marked a *return* to high reward in a successive high-low-high reward paradigm. The Crespi successive shift paradigm has recently been replicated (Benefield et al., 1974) with the addition of two improvements: (a) unlike Crespi and Zeaman, who used extrapolated asymptotes of preshift performance for comparison after all subjects had been shifted to the new incentive level, a high reward control group was maintained throughout the study; (b) a regimen for weight equalization was instituted, insuring that no significant differences in drive level could arise. The positive contrast effect which emerged out of this well-controlled study was attributed to release from frustration engendered by the interposed low reward experience (rather than elation over the high reward), an interpretation originally suggested by Crespi (1944) and in accord with Calef (1972).

The question now arises as to whether positive contrast can be successfully demonstrated using a simple low-high incentive shift pattern in which the subject does not receive prior exposure of any kind to the high reward condition. A number of studies have indicated the potential power of sucrose as an incentive motivator, combining as it does both sensory stimulation and drive reduction properties (Collier & Marx, 1959; Guttman, 1953; Ison & Glass, 1968; Pfaffman, 1960). The initial purpose of the present study is to determine whether sucrose as an incentive entity used in a simple incremental shift can reliably produce incentive contrast in the runway. Quantity and quality (concentration) of sucrose reinforcement will be varied to yield three preshift low to intermediate incentive groups in addition to one high reward nonshift control group.

If the use of sucrose in a simple incentive shift design results in positive contrast such enhanced performance would more likely be a function of an emotional response to reward increment than the release from frustration suggested by successive shift studies. The role of emotional conditioning in developing positive contrast will be examined by administering amobarbital sodium to additional low and high reward groups. Amobarbital sodium is a barbiturate drug, generally classified as a central nervous system depressant, having its primary effect on emotionally based behavior (Goodman & Gilman, 1965). If the administration of amobarbital sodium results in suppression of the PCE following incentive shift, positive contrast can be discussed in terms of a reaction to reward increment.

METHOD

Subjects. The subjects were 72 naive albino male Sprague-Dawley rats obtained at 90 days of age.

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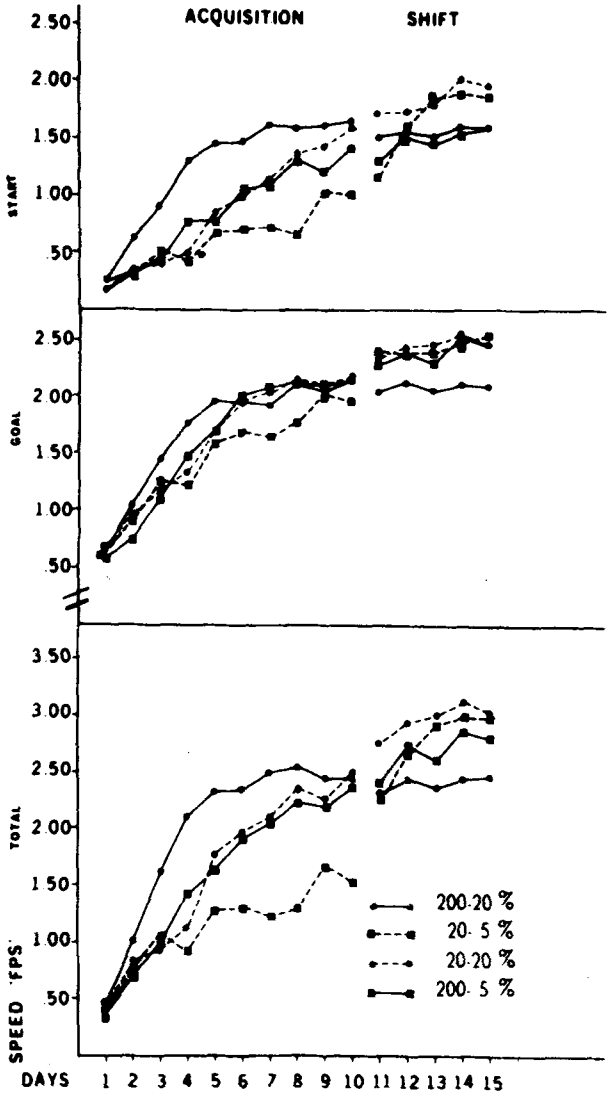

Figure 1. Mean start, goal, and total speeds as a function of days for various reinforcement groups during acquisition and incentive shift.

Apparatus. A straight black 84-in. runway described in Rosen (1966) was used. The startbox occupied 12 in., making the distance to be covered by the subject 72 in. A pair of photocells connected to a clock timer were activated by the opening of the start door. The timer was stopped automatically when the subject ran through the beam from a second pair of photocells placed on opposite side walls of the runway 6 in. from the start door. The time taken to traverse this 6 in. segment was divided by the distance and recorded as the start speed. Similar photocell units recorded the 6 in. of run time (the first photocells being 27 in. from the start door) and the 8.75 in. of goal time beginning 55 in. from the start door. Total running speed was calculated on the basis of the 63.75 in. distance from the start door photocells to the second goal-area photocells. A hole in one side of the goalbox admitted the appropriate drinkometer spout which was automatically withdrawn by solenoid action when the requisite number of licks had been applied by the subject. Tongue extension by the subject was necessary to obtain the sucrose solution and eliminated sucking on the spout. The speed with which the sucrose was consumed was measured by timers wired to the drinking spout. Initial consumption time was recorded for the first 20 licks by one timer, and duration of the full 200-lick reward was recorded by a second timer, where appropriate.

Procedure. A 23-h food deprivation schedule with ad-lib water was imposed 6 days before runway training. Subjects were handled for 3 min/day during this period. Sixty acquisition trials were divided into a 6 trials/day running schedule except for the first 3 days, when only two daily trials were assigned. Performance measures were taken from the first day. The 10-day acquisition period proceeded with subjects trained in squads of four with an interval of approximately 5 min. Ten min before the first trial, 1/3 of the subjects received a daily injection of amobarbital sodium (20 mg/kg, i.p.) and the remaining subjects (n = 48) were injected with equivalent volumes of sterile saline.

Four incentive categories were created by factorially combining two quantities of sucrose solution, derived from either 20 or 200 licks of the drinkometer spout, and two concentrations of sucrose, 5% or 20%. Two additional subject groups were run under the high reward condition (20%-200 licks) and the low reward condition (5%-20 licks) under the influence of amobarbital.

Following acquisition, 30 incentive shift trials were run over a 5-day period with all groups running to 200 licks of the 20% sucrose reward. Twenty-four extinction trials (6/day) in which subjects were detained in the goalbox for 3-5 sec were run for the high and low reward conditions in both the drug and normal groups. Three replications were necessary to complete the study.

RESULTS

Variation in Sucrose Reinforcement

Acquisition. Figure 1 presents mean running speeds for the start, goal, and total response measures for each day of acquisition and incentive shift training.

Subjects drank faster ($F = 27.30$, $df = 1/44$, $p < .001$) and ran faster ($F = 9.89$, $df = 1/44$, $p < .01$) for the higher sucrose concentration. Although animals ran significantly faster for 200 than for 20 licks ($F = 8.03$, $df = 1/44$, $p < .01$) there was no significant difference in initial drinking speed (the first 20 licks) between the 20-lick subjects and the ones who went on to complete 200 licks ($F = 2.11$, $df = 1/44$, $p > .10$). Running speed and sucrose consumption rate were analyzed for the 10 days of acquisition training, 5 postshift days, and 4 days of extinction using Winer's three factor experiment with repeated measures design (1962, pp. 337-349). Analyses of weight gain differences throughout acquisition yielded no significant effects ($F = 1.07$, $df = 12/620$, $p < .25$).

Incentive Shift. Positive contrast with the unshifted high reward group (200 licks-20%) was evident in all three shifted groups (Figure 1.) The group shifted from the 20 licks-20% reward was superior to all other groups in postshift performance, but the 20 licks-5% group showed the greatest increment in running speed compared with the preshift level. A significant licks effect was found in start ($F = 4.34$, $df = 1/44$, $p < .05$) and total ($F = 6.75$, $df = 1/44$, $p < .05$) speeds. Goal-speed response to the licks variable only registered a marginal level of significance of $p < .10$ ($F = 3.10$, $df = 1/44$); this figure most probably reflects a ceiling

effect in goal speed performance. Positive contrast was obtained in the goal speeds of all shifted groups on the first postshift trial. Start speed was much slower to reflect the changed incentive and a goal gradient effect was obtained in the experimental group shifted in both quantity and quality of reward (20-5% to 200-20%); the performance level can be seen to increase in relation to the control level as the behavior is traced from start to goal speed in Figure 1.

The largest PCE was produced by a change in the amount of reward (20-20% to 200-20%) and the smallest PCE resulted from a change in the concentration (200-5% to 200-20%). The effect was most evident in the total running speed measure (Figure 1). A change in both the amount and concentration of reward (20-5% to 200-20%) produced a PCE intermediate between the other two.

The shift to the high reward produced faster drinking speeds in all three of the shifted groups compared to their preshift performance during the first 20 licks of the sucrose solution. Only the group shifted in quantity of reward managed to exceed the drinking rate established by the high reward control group, in both initial and total drinking speeds. The other two shifted groups remained below the control drinking level in both measures. Sucrose concentration was a significant factor in determining both initial drinking speed ($F = 5.26$, $df = 1/44$, $p < .05$) and total drinking speed ($F = 4.70$, $df = 1/44$, $p < .05$) but drinking and running patterns were dissimilar.

Amobarbital Sodium

Acquisition. Figure 2 illustrates the instrumental response patterns of drug and normal groups to the high and low reward magnitudes. Drugged subjects tended to run faster but drink slower than normal subjects run under the high reward magnitude. Slower drinking rates also characterized drugged animals on low reward, but running speed relationships varied with alley segments. The slower drinking speed for drugged subjects was not statistically significant ($F = 2.60$, $df = 1/44$, $p > .10$) but the faster running speed found in drugged animals was significant for the total speed measure ($F = 4.35$, $df = 1/44$, $p < .05$). Reward magnitude was reflected in the magnitude of instrumental responding as well as in initial consummatory rate ($F = 39.47$, $df = 1/44$, $p < .001$) for all groups.

Incentive Shift. Figure 2 shows how the low reward drug group failed to respond to incentive shift with performance reaching that of the nonshifted high reward drug control group; in fact, shift performance was significantly lower than the control level in all parts of the runway. A PCE was, of course, completely lacking, but the significant differences between the low reward shifted drug group and the high reward drug control level represent a large negative effect, not just a failure to produce a positive contrast effect. The slopes of the low reward drug group and the low reward normal group were similar but the normal group remained above the performance level of the drug group throughout the incentive shift period, significant differences appearing in the goal and total measures.

Extinction. As can be seen in Figure 2, amobarbital sodium retarded extinction of runway performance in both the high and low reward magnitude categories. Significant differences between drugged and normal animals during extinction were noted in goal ($F = 12.71$, $df = 1/44$, $p < .001$) and total ($F = 9.77$, $df = 1/44$, $p < .01$) speed measures. A consistent difference in extinction behavior between high and low reward groups emerged when normal animals were compared but no such notable differences were evident in the drug groups. Both drug groups displayed much greater resistance to extinction than the normal groups throughout the four-day period of nonrewarded running.

DISCUSSION

The present findings indicate that positive contrast can be successfully demonstrated following a simple low-high incentive shift using a variety of sucrose reinforcers. Incentive quantity and quality factors were shown to exert a direct influence on the size of the PCE, with an increment in quantity of reward providing the largest contrast to the unshifted control and quality increment the smallest; changes in both incentive

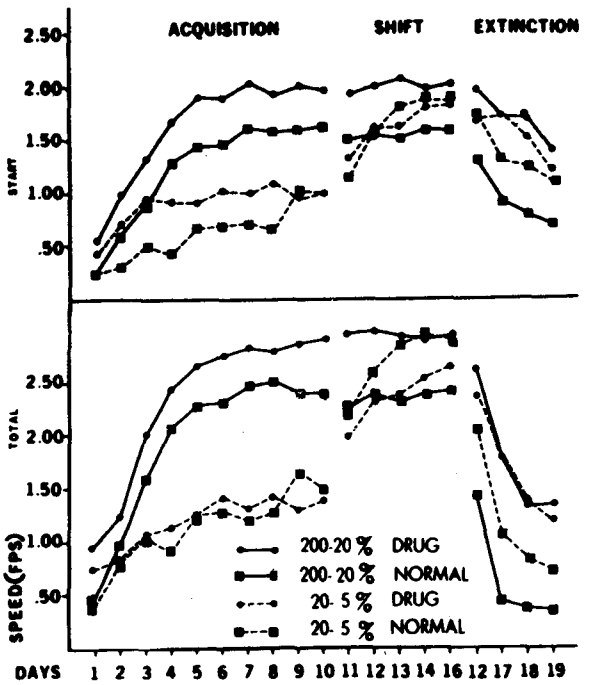

Figure 2. Mean start and total speeds as a function of days during acquisition, incentive shift, and extinction for drug and normal groups trained under high or low reinforcement magnitude.

dimensions resulted in an intermediate level of contrast.

The present finding that instrumental running speed is directly related to the concentration of sucrose solution and the amount of sucrose consumed agrees with the work of Goodrich (1960) and Kraeling (1961). The strength of the consummatory response was found to be a function of sucrose concentration, supporting the data of Kraeling and Rosen against the negative findings of Goodrich. Incentive shift brought increased consummatory speed to the shifted groups. According to Spence, the "vigor" of the unconditioned goal response (R_g), as reflected in consummatory behavior, should vary in relation to the magnitude of the incentive, and this is precisely what the present data illustrate. Further support for Spence's theory of incentive motivation can be found in the sensitivity of the goal speed measure to the new incentive magnitude; a PCE was obtained in the goal speeds of all nondrugged shifted groups on the first postshift trial.

Dunham and Kilps (1969) argue that drive differences, resulting from differentially changing weights in low reward as compared to high reward subjects, are responsible for the occurrence of the PCE. Weight was monitored in the present study, and although a small difference in body weights did emerge during acquisition training, this disparity between the low and high reward groups was not statistically significant (unlike the data reported by Dunham and Kilps).

The data from the second part of the study indicate that amobarbital sodium prevents the occurrence of the PCE following incentive shift. It would appear that in addition to attenuating the effects of frustrative nonreward and other emotional conditions (Miller, 1964), amobarbital reduces the emotional response to extreme positive changes in the experimental situation, as typified by a large increase in incentive magnitude.

The differential influence of amobarbital on start and goal speeds during acquisition and incentive shift may provide a clue to the operation of incentive motivation along various segments of the instrumental response chain in the runway. During acquisition, amobarbital increases start speed in both the high and low reward groups (in comparison with controls), and decreases goal speed, primarily in the low reward group. The superiority in start speed of drugged animals has been attributed to a reduction in emotional reactivity to disturbances caused by closing the startbox roof or opening the start door (Barry, Wagner, & Miller, 1962). The slower goal speed in the low reward drug group as compared to the normals during acquisition, and the sluggish response in goal speed to the increased reward magnitude apparent in the drug group following incentive shifting, support the hypothesis of amobarbital attenuation of emotional conditioning at the goal site.

An alternative hypothesis may be derived from Benefield et al.'s (1974) contention that frustration is a necessary precondition for positive contrast. If low incentive under strong drive conditions constitutes a frustrating situation then amobarbital can be regarded as dissipating this frustration, thereby preventing the development of a PCE. As in the Barry et al. (1962) study, amobarbital did function to inhibit extinction behavior in both the high and low reward groups (Figure 2), thereby supporting the frustration attenuation hypothesis of drug action proposed by Miller (1964), and, by implication, the theory that extinction results from conditioned frustration (Amsel, 1958). However, there is nothing in the present data to indicate the presence of frustration (due to low reward) during the acquisition period; therefore, an explanation of positive contrast in relation to simple emotional conditioning at the goal site seems appropriate for simple low-high incentive shift data.

The question of amobarbital action affecting the perceptual rather than the emotional system of the organism does not present serious competition with regard to the emotional hypotheses being used in the current explanations of the data. Perceptual motivation theories of the PCE do exist (Collier & Marx, 1959; Padilla, 1971), but studies using amobarbital in fear- and frustration-inducing circumstances (Gray, 1969; Miller, 1964), as well as in discrimination learning (Caul, 1967; Ison & Rosen, 1967), support the hypothesis that the drug has its primary effect on the emotional responses of the organism rather than upon perceptual or motor reactions. In any case, an examination of the present data with regard to the possible effect of amobarbital on perception reveals that incentive shift produces an increase in consummatory rate in drugged animals on the first postshift trial. It appears that the drugged animal is able to perceive the changed incentive and react accordingly.

The present investigation has indicated that a reliable PCE can be produced in the runway when a simple increment in sucrose reward is presented to the subject in the absence of prior experience with the high reward condition. The interpretation of positive contrast as an emotional response to incentive increment is supported by the action of the emotion attenuating drug, amobarbital sodium, in eliminating the PCE following incentive shift.

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