Negative contrast as a function of downshifts in magnitude of sucrose concentrations in thirsty rats

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In Experiment I, thirsty rats first received 1.50 cc of either 4% or 16% sucrose solution and later received .25 cc of the same solution as before. Control subjects received .25 cc of the appropriate solution throughout. In Experiment II, experimental subjects were shifted from 1.75 cc of 8% to .20 cc of the same solution, but all subjects were later given 1.75 cc sucrose reward. In neither experiment was a reliable negative contrast effect obtained. However, in Experiment II a significant positive-contrast-like effect was obtained. The results were discussed in terms of the older theories of Crespi and Helson as well as the new theory of Capaldi, all three of which emphasize a relative rather than an absolute view of reinforcement.

A negative contrast effect (NCE) is said to have taken place when subjects shifted from a large to a smaller reward perform at a significantly lower level than control subjects receiving the small reward all the time. Despite the consistent finding of NCE when solid food is downshifted, no such effect is obtained when either magnitude or concentration of liquid sucrose reward is downshifted (Goodrich, 1962; Homzie & Ross, 1962; Ison & Rosen, 1968; Rosen, 1966; Rosen & Ison, 1965). Moreover, even when both magnitude and concentration were downshifted simultaneously no NCE was reported (Barnes & Tombaugh, 1973; Flaherty, Riley, & Spear, 1973; Ison & Rosen, 1968). The consistent failure to obtain NCE when liquid sucrose is downshifted presents difficulties to two major interpretations of negative contrast. According to Amsel's frustration theory (1967), negative contrast occurs because of the decrement in performance of the downshifted subjects, which is attributable to the disruptive frustration responses made by these subjects when they receive small reward. These subjects experience frustration because presumably they had built up, through the r_g - s_g mechanism, an expectancy of large reward. On the other hand, Capaldi (1967) explains NCE by assuming that a shift from a large to a smaller reward represents a marked change in stimulus conditions, thus leading to a greater generalization decrement in the shifted relative to the nonshifted subject. Obviously, without further assumptions these theories cannot account for the consistent failure of obtaining NCE based on shifts in liquid sucrose. Proponents of Capaldi's generalization-decrement hypothesis have proposed that liquid sucrose leaves hardly any discriminable aftereffects so that downshifted subjects do not experience significantly less generalization decrement

than controls (Likely, Little, & Mackintosh, 1971; Rosen, 1966). Similarly, it could be assumed that shifts in liquid sucrose produce little, if any, frustration, thus accounting for the lack of NCE based on downshifts in liquid sucrose. But these new interpretations cannot account for the fact that NCE is nevertheless obtained with liquid sucrose when the dependent variable is the licking response (Vogel, Mikulka, & Spear, 1968), or the barpress response (Collier & Marx, 1959; Weinstein, 1970a, b).

It is obvious that our present theories would benefit greatly from studies that investigate the various empirical variables responsible for negative contrast. Few studies have addressed themselves to the study of the necessary and/or sufficient conditions for contrast. One such variable is suggested by the consistent finding of NCE based on downshifts in solid food reward when hungry rats are used. Is the state of deprivation a sufficient condition for negative contrast? In other words, does NCE occur whenever the state of deprivation is appropriate to the reinforcer used? If this is true, then it is not surprising that studies which used hungry rats failed to obtain NCE based on downshifts in liquid sucrose. The present study was designed to test the hypothesis that downshifts in liquid sucrose would be obtained when the subjects are appropriately motivated (i.e., thirsty).

EXPERIMENT I

Method

Design. A 2 by 2 factorial design was used in Phase 1 with half the subjects receiving 1.50 cc of either 4% or 16% sucrose solution, while the other half received .25 cc of either 4% or 16% sucrose solution. In Phase 2, the experimental subjects were shifted from 1.50 cc to .25 cc of the reinforcer. Concentration of the reinforcer remained constant throughout. In Phase 3, all groups underwent extinction.

Subjects. The subjects were 36 naive male albino rats of the Sprague-Dawley strain, approximately 80 days old at the beginning of the experiment.

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Apparatus. A standard Hunter runway was used. The runway was modified in two ways: First, the guillotine doors separating the start from the run and the run from the goal sections were converted from electrical to manual operation. Second, a black, self-sticking plastic coating covered the sides and ends of the runway from the outside. The top remained clear Plexiglas.

Four photocells were used to record start, run and goal times. The first photocell was located 8 cm into the runway from the start door. The second photocell was located 25 cm beyond the first, while the third photocell was placed 100 cm beyond the second photocell. The distance between the fourth and third photocell was 25 cm and was placed 8 cm into the goalbox. The photocells were connected to electric timers which measured time to the nearest one-hundredth second.

The lighting was supplied by two 25-W red light bulbs placed approximately 1.5 m over (but not directly above) the runway.

A clear plastic furniture coaster was used as the reinforcer cup which was 3.2 cm in diam and 6.3 mm deep. The sucrose solution was placed in the reinforcer cup by means of one of two hypodermic syringes which also served to measure the magnitude of the sucrose delivered. One syringe had a capacity of 1 cc and the other 2.5 cc. The needles were removed from both syringes.

Procedure. Upon arrival from the supplier, the subjects were housed individually and given 4 weeks free feeding. During this time, the subjects were weighed and handled daily. Two weeks prior to Phase 1, the subjects were adapted to a 23½-h water deprivation schedule, receiving ½-h free access to water in their home cages daily. Five days prior to Phase 1, the subjects were semirandomly assigned to one of the four groups, with the only restriction being that the mean weights of each group be approximately equal. Also at this time, the subjects were assigned to one of 12 squads of three subjects each. Groups were balanced across squads and position in a particular squad. Four days prior to Phase 1, all subjects received 2-min of free exploration in the unbaited runway with all equipment turned off and the guillotine doors open.

Three days prior to Phase 1, the subjects were given a second day of exploration for 1 min while all equipment was turned on. The subject was placed in the startbox, the door of which was raised as soon as the subject oriented toward it. On the following 2 days, operant levels were taken by measuring the time taken by each subject to traverse the entire runway on the first run. No reinforcement was given during the exploration trials.

On Day 1 of Phase 1 a single reinforced trial was given, followed by two trials on Day 2 and three trials per day thereafter. On each trial, each subject was taken out of its home cage, brought to the adjoining experimental room and then returned to the home cage upon completion of each trial. The subjects were run in squads of three with an ITI of approximately 3-5 min. In the event that a subject spent more than 30 sec in any given section of the runway without moving on to the next, the subject was gently pushed to the next section and a time of 30 sec was recorded for the previous section. During this phase, each subject received one of four reinforcement conditions: (1) 1.50 cc of 4% sucrose solution; (2) .25 cc of 4% sucrose; (3) 1.50 cc of 16% sucrose; (4) .25 cc of 16% sucrose. The reinforcement consisted of commercial sugar and water mixed 24 h prior to use and stored at room temperature. The 4% solution was made by mixing 4 g of sugar with 100 cc of water, and the 16% solution was made by mixing 16 g of sugar with 100 cc of tap water. Each subject received ½-h access to water in its home cage at least 30 min after its last daily trial. Each subject received 36 trials in Phase 1. In Phase 2, those subjects receiving 1.50 cc rewards in Phase 1 were shifted to .25 cc of their respective Phase 1 concentrations. The two groups receiving .25 cc sucrose on Phase 1 served as the nonshifted control groups. Phase 2 lasted 11 days for a total of 33 trials. Phase 3 consisted of 4 extinction days (12 trials). On each extinction trial, the subject ran to an empty goalbox and was confined there for 10 sec.

Results

All time measures were converted into reciprocals and multiplied by the appropriate length of alley to obtain speed measures. A statistical analysis of the start or run measures revealed that no NCE occurred in either section throughout the shift phase. However, an apparent NCE was observed in the goal section during the first six blocks of Phase 2, but disappeared thereafter.

A two-way analysis of variance with repeated measures over the first six blocks revealed a significant magnitude effect in the goal measure [$F(1,32) = 4.75$, $p < .05$]. Neither the concentration effect nor the interaction of the two main factors was significant, both $F_s < 1$. The blocks effect was significant [$F(5,160) = 5.45$, $p < .01$], but neither the interaction of Blocks by Magnitude, $F < 1$, or with concentration was significant [$F(5,160) = 1.11$, $p > .05$]. The triple interaction of Blocks by Magnitude by Concentration was similarly not significant [$F(5,160) = 1.02$, $p > .05$]. After the sixth block, no significant magnitude, concentration, or magnitude by concentration effect was found in the goal section [$F_s(1,32) < 1$].

The performance of the subjects in all sections of the runway in Phase 3 was highly similar. Therefore only the results of the total speed analysis will be reported. A two-way analysis of variance with repeated measures over all four blocks of Phase 3 showed nonsignificant results for each of the magnitude, concentration, and magnitude by concentration interaction effects, all $F_s(1,32) < 1$. The blocks effect was highly significant [$F(3,96) = 114.52$, $p < .001$], reflecting a reliable extinction effect for all groups. However, the interaction of blocks with either magnitude or concentration was not significant, both $F_s < 1$. Moreover, the (triple) interaction of blocks with both magnitude and concentration was not significant [$F(3,96) = 1.20$, $p > .05$].

Discussion

The NCE observed in this study was temporary and confined to the goal section. More importantly, the effect was probably an artifact. Specifically, the NCE observed was apparently due to an observed increase in the speeds of the nonshifted control groups rather than to the slight decrease in speeds of the downshifted groups. Both increases and decreases were temporary. Moreover, no NCE was detected in any speed measure during extinction. Thus, a second experiment was run to test the reliability of the negative-contrast-like effects observed in Experiment I.

EXPERIMENT II

Method

Design. Two independent groups of subjects received either large or small 8% sucrose solutions in Phase 1. Both groups received small reward in Phase 2 followed by large reward in Phase 3. The sucrose concentration remained constant throughout.

Subjects. The subjects were 30 naive male albino rats of the

Sprague-Dawley strain, approximately 90 days old at the start of the experiment.

Apparatus. The same Hunter runway used in Experiment I was used in Experiment II with no alterations whatsoever.

Procedure. The general handling, deprivation, exploration, and other preliminary procedures were the same as those used in Experiment I.

On Day 1 of Phase 1, each subject received a single trial reinforced with either 1.75 cc or .20 cc 8% sucrose solution, followed by two such trials on Day 2 and three trials per day thereafter. Starting with Day 2, subjects were run in squads of three with an average ITI of 2 min. Each subject in Phase 1 received 36 trials. In Phase 2, the subjects previously receiving 1.75 cc sucrose reward received .20 cc of the same reward, while those receiving .20 cc continued to receive the same reward magnitude. In Phase 3, all subjects were shifted from .20 cc to 1.75 cc sucrose reward. Throughout the study, 8% sucrose concentration was used by mixing 8 g of sugar with 100 cc of tap water.

Results

All speed measures yielded highly similar results. However, the analyses reported here are based on the total speed.

The two groups differed significantly over the last three blocks of Phase 1 [$F(1,28) = 6.05, p < .01$], but the blocks effect was not significant [$F(2,56) < 1$]. Similarly the Blocks by Magnitude effect was not significant [$F(2,56) = 1.14, p > .05$]. As Figure 1 shows, no sign of NCE was evident throughout Phase 2. An analysis of variance test performed over Blocks 1-9 of Phase 2 showed nonsignificant effects for magnitude, $F < 1$, as well as for blocks [$F(2,56) = 2.50, p > .05$], and the interaction of Blocks by Magnitude [$F(2,56) = 1.38, p > .05$]. In Phase 3, the magnitude effect was significant [$F(1,28) = 4.47, p < .025$], as was the blocks effect [$F(2,56) = 15.21, p < .001$]. The interaction effect of Blocks by Magnitude, however, was not significant [$F(2,56) = 1.70, p > .05$].

Discussion

The present study has yielded two main results. On the one hand, the finding that no NCE was obtained when thirsty rats were shifted from large to smaller liquid sucrose reward supports the hypothesis that the NCE obtained in Experiment I was probably an artifact and thus unreliable. On the other hand, when both groups received large reward in Phase 3, the experimental group, which received large reward in Phase 1 before being shifted to small reward in Phase 2, ran significantly faster than the control group that experienced small reward in both Phases 1 and 2 before the shift to large reward in Phase 3. This is in agreement with the results of two similar studies which used food rather than sucrose reward (viz. Benfield, Oscos, & Ehrenfreund, 1974; Shanab & Ferrell, 1975). Unlike the latter two studies, this experiment did not employ a control group which received large reward all the time, but the results may nevertheless be considered a special case of PCE. Actually, on the assumption that the group which was shifted to large reward after a history of small reward must have experienced PCE, the present finding probably underestimates the actual magnitude of the PCE reflected by the experimental group. At worst, if it is assumed that no PCE could have taken place between the present control group and a regular large rewarded group, the elevated performance of the experimental group must be considered as reflecting positive contrast.

Figure 1. Mean total speed as a function of a downshift and a subsequent upshift in magnitude of liquid sucrose.

GENERAL DISCUSSION

The results of the preceding two experiments show clearly that, like hungry rats, thirsty rats do not exhibit negative contrast when a reduction in the magnitude of liquid sucrose reward is made. Since several magnitudes (.20, .25, 1.50, and 1.75 cc) and concentrations (4%, 8%, and 16%) were used in both experiments, the lack of NCE, even when the reinforcer was appropriate to the motivational state of the animals, presents difficulties for the various theories discussed herein. More empirical investigations of the determinants of negative contrast based on downshifts in liquid sucrose need to be made in order to enhance our understanding of this phenomenon. For example, it has been reported that water deprivation is less "motivating" than food deprivation in that rats deprived of either food or water for the same period of time perform at a higher rate when hungry than thirsty (Logan & Spanier, 1970; MacDonald & Toledo, 1974). It is conceivable that shifts in liquid sucrose are not perceived as readily as shifts in solid reward. To enhance the perceptual differences between the shifted and nonshifted concentrations or magnitudes of sucrose, several variables need to be manipulated. Negative contrast can be studied as a function of very large incentive differences between shifted and nonshifted sucrose rewards, as well as increased motivational level which can be produced by depriving subjects of water for extended periods of time (e.g. 47 h or more), or of both water and food.

The finding of positive-contrast-like effects in Phase 3 of the second experiment may be viewed as providing further evidence of the inadequacy of the absolute view of reinforcement. According to the explanation offered by Benfield et al., which is based on Crespi's earlier formulations, a PCE occurs only if the organism has already experienced a frustratingly small reward before experiencing large reward again. Conversely, a NCE occurs only when the organism has had commerce with a large reward of high "eagerness" value before receiving small reward again. It can be argued that such conditions also serve to enhance the perceptual differences between the shifted magnitudes or concentrations of liquid sucrose. Capaldi (1974) recently proposed that positive (or negative) contrast is a function of the discrepancy between expected and obtained reward. If the expected is below the obtained reward, positive contrast should result, while negative contrast is predicted when expected is greater than obtained reward. It should be recognized that this new line of theorizing based on reinforcement level is not only similar to Crespi's earlier theory of eagerness (1944) but also to Helson's adaptation-level theory (1964). Helson (1964) similarly proposed that a PCE would occur whenever the obtained reward condition is greater than that expected on the basis of the

adaptation level already formed by the organism as a result of experience with past reward conditions. Thus all three preceding theories can account for the present results in Phase 3 as well as for those obtained by Benefield et al. (1974) and Shanab et al. (1975). However, all three theories face the challenge of explaining the lack of NCE in this and other experiments in which liquid sucrose was downshifted.

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