Pharmacology Biochemistry & Behavior, Vol. 7, pp. 315–322.

Incentive Contrast Undiminished by Extended Testing, Imipramine, or Chlordiazepoxide[1]

CHARLES F. FLAHERTY,[2] BRUCE R. LOMBARDI, JEFFRY KAPUST AND M. R. D'AMATO

Rutgers University, New Brunswick, NJ 08903

(Received 27 April 1977)

FLAHERTY, C. F., B. R. LOMBARDI, J. KAPUST AND M. R. D'AMATO. *Incentive contrast undiminished by extended testing, imipramine, or chlordiazepoxide.* PHARMAC. BIOCHEM. BEHAV. 7(4) 315–322, 1977. – In three experiments rats were given alternating 1-minute access periods to two tubes containing sucrose solutions. When the tubes contained disparate concentrations (32% versus 4%), lick-rate was higher for the 32% solution than it was when both tubes contained 32% (a positive contrast effect) and less for 4% than when both tubes contained 4% (a negative contrast effect). Similar, but generally less pronounced, contrast effects were obtained in latency to initiate drinking. These contrast effects showed no sign of diminution with repeated exposure (32 days of repeated shifts in Experiments 1 and 3); they were not greatly influenced by injections of imipramine (Experiment 2) or chlordiazepoxide (Experiment 3), nor by deprivation conditions (Experiment 3). The results supported an explanation of simultaneous contrast in terms of sensory-perceptual processes rather than in terms of generalization decrement or emotional responses.

Incentive contrast Imipramine Chlordiazepoxide Reinforcement shift Sucrose
Consummatory behavior Deprivation

ANIMALS exposed to different levels of reward often perform differently from animals exposed to only a single level of reward. For example, animals shifted from a large to a small reward generally perform more poorly for that reward than animals exposed to only the smaller reward. Conversely, animals shifted from a small to a larger reward often perform at a higher level than animals exposed to only the larger reward. These differences in behavior, termed incentive contrast effects, have been found in a variety of experimental paradigms and with a variety of animals [10, 17, 24, 26]. Despite the widespread demonstration of incentive contrast, there is no general agreement concerning the responsible mechanisms. Contrast effects have been interpreted in terms of emotional responses, associative processes, and sensory-perceptual processes.

Those favoring an account of contrast in terms of emotional responses have sometimes offered one, and sometimes two, emotional states as causally related to contrast. For example, negative contrast (poorer performance) has been interpreted in terms of frustration-related responses that interfere with the performance of an instrumental response [7, 9, 10]. Positive contrast (enhanced performance), on the other hand, has sometimes been interpreted in terms of a positive emotional response, elation, and sometimes in terms of an energizing (rather than an interfering) effect of frustration [30]. This last interpretation is consonant with views of positive behavioral contrast that postulate the occurrence of inhibition during exposure to the lower level of reward and a release from inhibition that occurs when the large reward, or stimuli signaling the large reward, are encountered [25].

Interpretations of contrast in associative terms have emphasized the presumed role of generalization decrement in negative contrast [6]. The reasoning here is that a reward is one stimulus among many in which an instrumental response is learned and that a change in reward, much as a change in any contextual stimulus, will result in a temporary decrement in behavior [20]. It is apparent that this account of incentive contrast is limited to negative contrast, since the occurrence of generalization decrement could only detract from positive contrast.

Finally, incentive contrast has also been attributed to the operation of sensory-perceptual factors presumably similar to those producing perceptual contrast in humans [4,12]. An interpretation of incentive contrast in these terms implies that contrast effects occur because of a

[1] This research was supported by a Biological Sciences Support Grant and by a grant from the Rutgers Research Council and by NSF Grant GB 401110. The assistance of Barry Bradford in conducting Experiment 1 and Michael Caprio in conducting Experiment 2 is appreciated.

[2] Reprint requests should be addressed to Charles F. Flaherty, Psychology Department, Busch Campus, Rutgers University, New Brunswick, NJ 08903.

misperception of the postshift reward; for example, a negative contrast effect may occur following a shift from a large to a small reward because the postshift reward appears smaller to the shifted animals than it does to unshifted controls.

In the present paper we present three experiments which examine some implications of the various theoretical interpretations of contrast in the context of a paradigm in which both positive and negative contrast occur reliably.

EXPERIMENT 1

Positive and negative contrast effects are readily obtained when rats are allowed alternating access to two drinking tubes contraining different concentrations of sucrose solutions: with different sucrose solutions in the two tubes, the rats lick more for the high concentration than they do when both tubes contain only the higher concentration (a positive contrast effect); they lick less for the lower concentration than when both tubes contain only the lower concentration (a negative contrast effect). The bidirectional contrast effects occur when the same animals serve under both contrast and control conditions and when separate groups of animals serve as controls for positive and negative contrast [13,14].

The purpose of the first experiment was to assess the durability of contrast obtained in this paradigm. Although the predictions are not entirely unambiguous, the different theoretical interpretations of contrast seem to imply different degrees of durability. For example, the generalization interpretation seems to imply the least durable contrast, and a sensory-perceptual account the most durable. The basis of these predictions will be considered after the results have been presented.

Method

Animals. Ten naive male rats approximately 100 days old were used. Five of these rats were purchased from the Sprague-Dawley Company of Madison and five were Sprague-Dawley derived rats purchased from Blue Spruce Farms of Altamont, New York. The rats were reduced to 85% of their free feeding weight and maintained at that level by once-a-day feeding throughout the experiment. Water was always available in the home cage.

Apparatus. Testing was conducted in a Plexiglas chamber measuring 30 × 25 × 25 cm. On one side of the chamber there were two centrally located 1.5 cm dia. holes spaced 21.7 cm apart and 4 cm above the wire mesh floor. Two graduated drinking tubes, located outside the chamber, were programmed so that either tube could automatically be moved into a drinking position in which the orifice of the drinking spout was centered in the 1.5 cm dia. hole, flush with the outside wall of the chamber. Pilot lights, mounted on either side of the chamber near the drinking access holes, were illuminated whenever the tube in closest proximity to that light was in the drinking position. A contact relay circuit was used to measure the licking response.

Procedure. On each test day the rat was placed in the apparatus with the left tube in the drinking position; the tube remained available for a 1-min period starting from the time of the first lick. At the termination of this period the left tube retracted and the right tube moved in for a 1-min period, timed from the first lick. The right tube then retracted and the left tube again became available. This procedure continued for a total of 3 presentations of each tube.

The sucrose solutions contained in the drinking bottles were varied across days in four-day cycles. On two days of each cycle both bottles contained the same solution, 32% on one day and 4% on the other. On the remaining two days one bottle contained the 32% solution and the other contained the 4% solution. On one of these days the 32% solution was in the left bottle and on the other day it was in the right bottle. Eight four-day cycles were presented. Within each four-day cycle the actual sequence of sucrose conditions was randomized, as was the running order of the rats. The sucrose solutions were prepared by weight (solute/solute + solvent) from commercial grade cane sugar and tap water. New solutions were mixed every four days and were presented at room temperature.

Data recorded included (a) the number of licks made during each 1-min period, and (b) the latency of the first lick when the bottles were changed. The data from the last 4-min only of each session will be reported. The conditions of interest are comparisons of lick rates when (a) both bottles contained 32% (32–32), (b) both bottles contained 4% (4–4), and (c) one bottle contained 32% solution and one bottle contained the 4% solution. The data for the latter condition were obtained by averaging across position (and therefore days) to obtain lick-rate for 32% when the alternative bottle contained 4% (32–4), and lick-rate for 4% when the alternative bottle contained 32% (4–32).

Results

Lick rate. The mean lick rates obtained over the last four minutes of each session are presented as a function of sucrose conditions in Fig. 1. The results obtained with the two groups of Sprague-Dawley derived rats were virtually identical and, therefore, the two groups were combined for data presentation and analysis.

A clear ordering of lick rates as a function of concentration condition is apparent in Fig. 1. The rats licked more for the 32% solution when the alternative tube contained 4% than they did when both tubes contained 32%, $F(1,9) = 277.60$, $p<0.001$. Furthermore, it is apparent that this positive contrast effect showed no signs of diminishing over the eight test cycles. Subsequent analysis of a reliable Concentration X Cycle interaction, $F(7,63) = 6.50$, $p<0.01$, by Fisher's lsd test ($p = 0.05$, two tail) indicated that the positive contrast effect was reliable in all cycles except Cycle 2.

The results obtained in the negative contrast conditions were similar; the rats licked less for 4% when the alternative tube contained 32% than they did when both tubes contained 4%, $F(1,9) = 245.20$, $p<0.001$. Again, subsequent analysis of a reliable Concentration X Cycles interaction, $F(7,63) = 7.18$, $p<0.01$, by Scheffe's test for post hoc comparison [22] indicated that the contrast effect was greater over the last four cycles than it was over the first four (obtained t of 4.34 greater than critical t of 3.74 necessary for significance at $p<0.05$).

Finally, it should also be mentioned that the rats licked more for the 32% under control conditions (32–32) than they did for 4% under control (4–4) conditions, $F(1,9) = 212.70$, $p<0.001$.

Latency. Examination of the latency to initiate drinking after the tubes had been switched indicated that the animals took longer when switching to a 4% tube from a

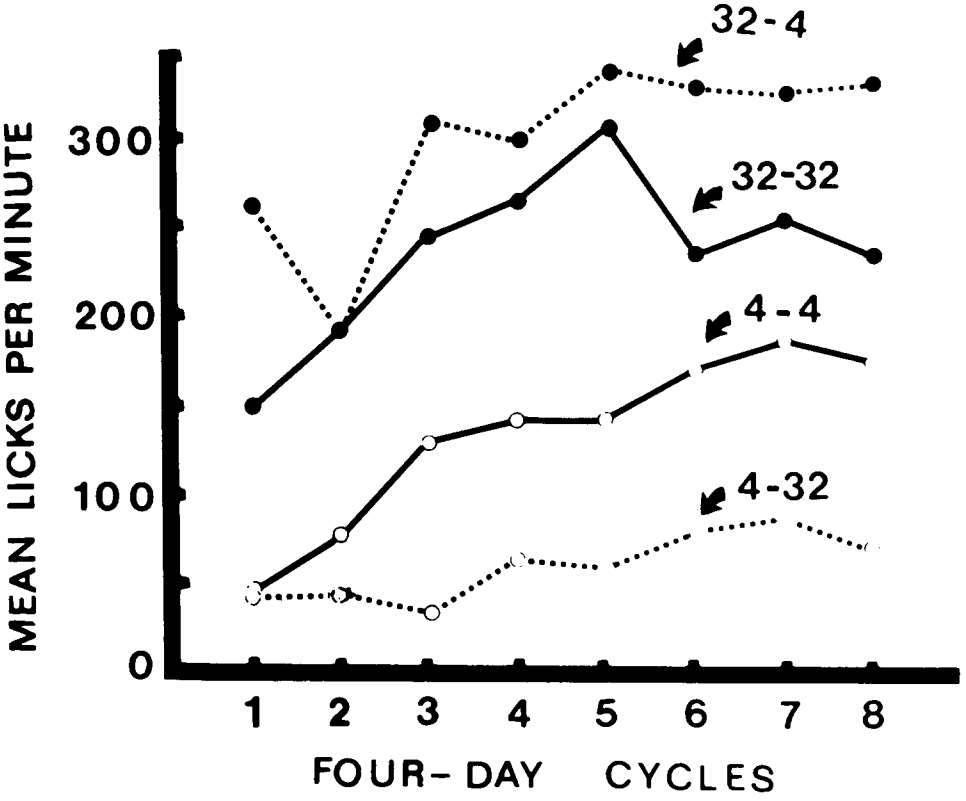

FIG. 1. Mean lick rate as a function of sucrose concentration condition and test cycle. The curve labeled 32–4 presents the lick rate for 32% sucrose when the alternative tube contained 4%, etc.

tube containing 32% than they did in switching between two 4% tubes on control days, $F(1,9) = 86.19$, $p<0.01$. There was also an indication of a small, but statistically reliable positive contrast effect in latency; that is, the latency to initiate drinking was shorter when the animals were switching from a 4% tube to a 32% tube than it was when they were switching between two 32% tubes, $F(1,9) = 20.42$, $p<0.01$. The contrast in latency developed considerably more slowly across cycles than did the contrast in lick-rate, results that are similar to those presented in Flaherty and Largen [14].

Discussion

The reliable positive and negative contrast effects obtained in this experiment remained unabated over a 32-day test period with repeated shifts between high and low concentrations of sucrose solutions. These results, together with those obtained by Flaherty and Largen [14] indicate quite strongly that the contrast effects obtained in the present paradigm will remain as long as differential sucrose solutions are presented.

These data, we think, do not favor a generalization decrement account of the contrast obtained in the present experiment. Taken at face value, a generalization decrement explanation of contrast predicts that only negative contrast should occur and that this contrast should be temporary; once the animals have had experience with the different reinforcing stimuli, then contrast should dissipate [6]. The present data seem incompatible with this view.

An interpretation of contrast in sensory-perceptual terms can be conceptualized in either of two ways. It is possible that the intake of one solution could directly influence the taste of the second solution through a direct sensory interaction [23], or through a more indirect process such as that incorporated into Helson's adaptation-level theory [1,19]. In either case, contrast effects ought to be bidirectional and enduring, as found in the present experiment.

The predictions that derive from an interpretation of contrast in terms of emotional responses are not very clear [12]. Variants of Amsel's frustration theory have often been applied to negative contrast obtained in runway situations [8]. Such an application would imply that negative contrast should eventually wane as interfering stimuli elicited by frustration become counterconditioned to the instrumental response [12]. That clearly was not the case in the present experiment either for the lick rate measure or the latency measure. Nor, has it been the case in many runway studies of simultaneous contrast [15].

Although the contrast effects in the present paradigm were not at all transitory, it is still difficult to dismiss completely the possibility that emotional responses are involved in the contrast effects obtained in the present experiment. This reluctance stems, in part, from the evidence developed in other contrast paradigms indicating that emotional responses do play a part. For example, Goldman, Coover and Levine [17] reported increased adrenocorticosteroid output in an operant negative contrast paradigm and decreased output in an operant positive contrast paradigm. Moreover, contrast has been attenuated by the administration of chlordiazepoxide [29], barbiturates [28], and anti-depressant agents [5]. The degree of confidence that emotional responses are involved in at least

some contrast paradigms can be estimated from recent articles advocating a contrast paradigm for the testing of the emotion-influencing effects of drugs, particularly antidepressants [2,21].

In order to investigate further the possible role of emotional factors in the contrast obtained in the present paradigm, a second experiment employing an antidepressant drug was conducted.

EXPERIMENT 2

Tricyclic anti-depressants have been shown to alter contrast effects in some situations. For example, Bloomfield [5] found that a dose of 5 mg/kg of desmethylimipramine hydrochloride abolished positive behavioral contrast effects that normally occurred in pigeons. In several experiments Bloomfield attempted to relate contrast to the development of inhibition in the presence of the negative stimulus (S−) and the absence of contrast under drug influence to the reduction of this inhibition. The results of these experiments did not provide complete support for the notion that inhibition during S^- was necessary for contrast (see also [18]). However, Bloomfield did note that "relative contrast level does correlate with relative disinhibition through drug injection ([5], pp. 177). Other experiments have indicated apparent disinhibitory effects of imipramine in operant situations [11,32], and Terrace [31] has postulated that the effects of such drugs as imipramine and chlorpromazine on S^- responding may operate by reducing the aversiveness of S^-.

In the present experiment we report an investigation of the effects of imipramine on positive and negative contrast obtained in the same paradigm as that used in Experiment 1. If the negative contrast effect obtained with this procedure is related to inhibition of depressive emotional states, then imipramine should act to reduce negative contrast. The effects of the drug on positive contrast are not readily predictable. If positive contrast is related to inhibition developed with regard to responding to the less concentrated solution, then positive contrast should also be reduced by the drug. On the other hand, if positive contrast is related to a positive emotional state (elation), there perhaps should be no effect of the drug.

Method

Animals. Six male Sprague-Dawley rats purchased from Charles River Breeding Farms were used. The rats were reduced to 80% of their free-feeding weight and maintained at that level by once-per-day feeding throughout the experiment. Water was always available in the home cage.

Apparatus. The apparatus was the same as that used in Experiment 1.

Procedure. The procedure was essentially the same as that employed in Experiment 1, except for those aspects related to drug administration. The rats were first tested for two cycles exactly as in Experiment 1 with no drug administration. Over the next three cycles, 30 min prior to testing, the rats were injected IP with isotonic saline, 8 mg/kg, or 16 mg/kg of imipramine (Tofranil HCL, Ciba-Geigy, Summit, NJ). All animals received each drug treatment, and the order of administration was varied according to a latin square plan, with the same square repeated twice (three animals per square). Each drug condition was administered for the full four-day cycle of contrast and control conditions. The order of sucrose conditions within a cycle was randomized, and there was a three-day break between each four-day testing cycle.

Results

Lick rate. The results obtained over the first two (non-drug) cycles of the experiment were the same as those obtained in Experiment 1 and in earlier experiments, that is, there were reliable positive and negative contrast effects.

The mean lick rates obtained for each min of each concentration pair under the various drug conditions are presented in Fig. 2. It is apparent that positive and negative contrast effects developed in all conditions. Analysis of the last two min of the positive contrast pairings showed that the animals licked at reliably higher rates for 32% when it was paired with 4% than they did when both tubes contained 32%, $F(1,5) = 11.90$, $p<0.05$. Imipramine injections led to marginally reliable decline in overall lick rate in the 32–32 and 32–4 conditions, $F(2,10) = 4.01$, $p<0.07$.

Analysis of the negative contrast conditions indicated that the rats licked reliably less for 4% sucrose when it was paired with 32% than they did when both tubes contained 4%, $F(1,5) = 28.82$, $p<0.01$. No overall drug effect was obtained in the negative contrast conditions ($F<1.00$); however there was a reliable Drug × Concentration interaction, $F(2,10) = 4.99$, $p<0.05$, indicating that the degree of negative contrast was reduced by the higher dose of imipramine. Subsequent analysis of this interaction with Fisher's least significant difference (lsd) test ($p = 0.05$, two tail) indicated that contrast, although reduced in the 16 mg/kg condition, was still statistically reliable. As is apparent from Fig. 2, the reduction in negative contrast did not come about solely by way of an increase in lick rate in the contrast (4% versus 32%) condition – there was also a decline in lick rate in the control condition (4% versus 4%). Neither of these changes, considered separately, represented a statistically reliable change from the saline or 8 mg/kg conditions (by lsd test). Further examination of individual animal's behavior showed that all six animals exhibited negative contrast in both saline and 8 mg/kg conditions, but only four of the six animals demonstrated numerical negative contrast effect in the 16 mg/kg condition. In the two animals in which contrast was lost, this loss was brought about both by a decrease in lick rate in the control conditions and an increase in lick rate in the contrast conditions, a pattern that also generally held for the four animals that maintained contrast.

Latency. The latency to initiate drinking when the alternative tube became available showed no signs of positive contrast effect ($F<1.00$) nor of a drug effect under the positive contrast conditions ($F<1.00$). However, there was a negative contrast in latency; the animals took longer to initiate drinking when switching from a 32% condition to a 4% condition than they did switching back and forth between 4% conditions $F(1,5) = 7.42$, $p<0.05$. There was no overall drug effect, $F(2,10) = 1.65$, $p>0.20$, nor was there a reliable Drug × Concentration interaction, $F(2,10) = 2.98$, $p>0.05$.

Discussion

The present experiment again demontrated the reliable occurrence of bidirectional contrast and further indicated an apparent decrease in the degree of negative contrast

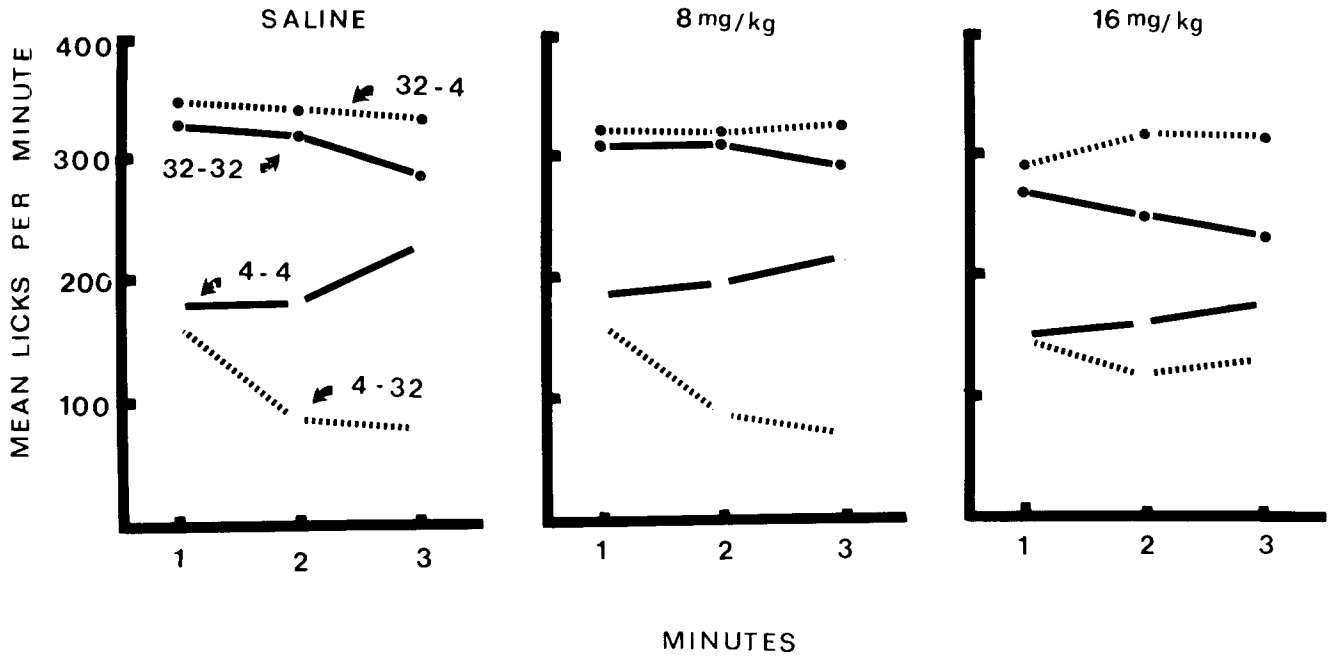

FIG. 2. Mean lick rate as a function of sucrose concentration condition, dose level of imipramine, and minute of the test cycle. The abscissa refers to the access period to each pair of concentrations. On control days, when both tubes contained the same solutions (either 32% or 4%), the data points refer to the mean lick rate on the two tubes. On contrast days, when the tubes contained disparate solutions, the data points refer to the lick rates obtained at each tube.

following an injection of 16 mg/kg of imipramine. Positive contrast was not diminished by this drug dose, nor was either contrast influenced by an 8 mg/kg injection of imipramine.

It is difficult to interpret the effects of the large imipramine dose on negative contrast. On the one hand, the reduction of negative contrast by imipramine would be consistent with an emotional interpretation of contrast. However, the reduction was not complete, even with a large dose of imipramine and, furthermore, the way in which the reduction occurred does not provide convincing evidence that an aversive emotional response is being alleviated by the drug. That is, the diminution of negative contrast seemed to be as much due to a decrease in lick rate in the control conditions (4–4) as to an increase in lick rate in the contrast condition (4–32). This relationship was also clear in the latency measure of negative contrast – the speed of initiating drinking became slower in the control conditions rather than much faster in the contrast conditions.

All-in-all, the results of the present experiment and of Experiment 1 are not favorable to an emotional interpretation of the contrast effects obtained in the present paradigm. However, because of the somewhat ambiguous nature of the results obtained with the 16 mg/kg dose of imipramine, an additional experiment was conducted.

EXPERIMENT 3

One drug that has had clear effects on incentive contrast obtained in runway experiments is chlordiazepoxide. Rosen and Tessel [29] have shown that chloridiazepoxide in doses of 5 and 10 mg/kg eliminated a negative contrast effect that normally occurred when the reinforcement for running in a runway was shifted from 15 food pellets to a single pellet. Injections of saline or a 2.5 mg/kg dose of chlordiazepoxide did not influence the contrast effect. Rosen and Tessel related the effectiveness of chlordiazepoxide in reducing contrast to a presumed ameliorative effect of the drug on aversive emotional states. There is also some evidence that chlordiazepoxide reduces successive negative contrast when the reward shift involves a change in the concentration of sucrose solutions rather than a shift in number of food pellets [33].

On the basis of these data, it appeared that a further study investigating the effects of chlordiazepoxide in our bidirectional contrast paradigm would provide useful information concerning the contribution of emotional factors to positive and negative incentive contrast.

Method

Animals. Eight naive male albino rats derived from the Sprague-Dawley strain were used. The rats were approximately 100 days old at the start of the experiment.

Apparatus. The apparatus was the same as that used in the previous experiments.

Procedure. Details of the procedure, except for those involving manipulation of the drug and deprivation conditions, were similar to the previous two experiments.

In the present experiment half of the animals were deprived to 80% of their free-feeding weight and maintained at that level throughout the experiment. The remaining rats were allowed free access to food in their home cages for the duration of the experiment. Both deprived and ad lib rats had free access to water in their home cages.

All animals were tested for four cycles (a cycle defined as exposure to all four sucrose concentration conditions, as in previous experiments) prior to any drug administration. The next four cycles were drug cycles during which the rats were injected with chlordiazepoxide hydrochloride (fur-

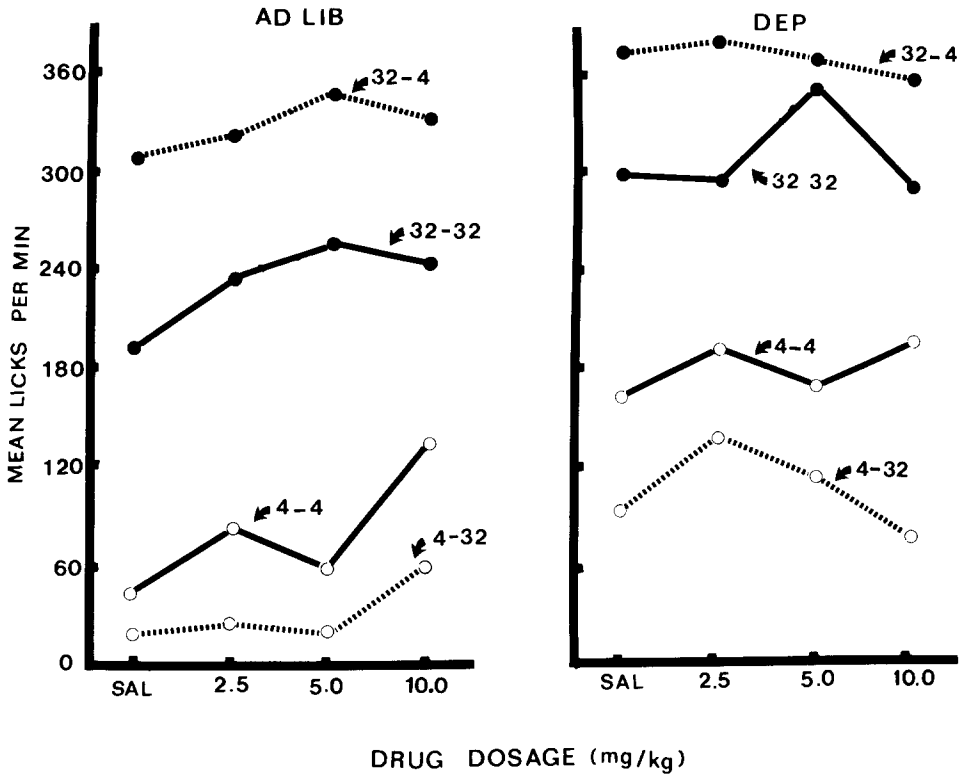

FIG. 3. Mean lick-rate as a function of sucrose concentration condition, deprivation condition, and dosage level of chlordiazepoxide. Concentration designations are as in the previous experiments.

nished by Hoffmann-La Roche Inc., Nutley, NJ) or with physiological saline. The drug doses injected were either 2.5, 5.0 or 10.0 mg/kg of chlordiazepoxide or an approximate volume equivalent of saline. The drugs were mixed on a mg/ml basis, and injections were given IP 30 min prior to the start of each test session. The order of administration of the drugs was varied according to a 4 × 4 latin square plan. Rows of the square corresponded to animals and drug sequence; columns of the square corresponded to test cycles, during each of which the four sucrose concentration conditions (32–4, 32–32, 4–32, 4–4) were varied randomly.

To summarize the experimental design, drug condition and sucrose concentration condition were varied within animals, whereas deprivation condition was varied as a between-subjects factor orthogonal to the drug and deprivation conditions. Both ad lib and deprived animals received the same sequence of drug injections. There was a three-day break between each four-day test cycle.

Other aspects of the procedure were the same as those employed in the previous two experiments.

Results

Lick rate. Figure 3, presents the mean lick rate as a function of sucrose concentration conditions, deprivation conditions, and drug treatment conditions. It is apparent from the figure that both positive and negative contrast effects were again obtained and that the degree of these contrast effects was not strongly influenced by either deprivation conditions or by chlordiazepoxide injection.

A latin square analysis of variance, with concentration as an orthogonal factor, conducted on the data obtained from the ad lib animals indicated a highly reliable effect of sucrose concentration on lick-rate, $F(3,24) = 153.40$, $p<0.001$. Subsequent analysis of these data with Fisher's lsd test ($p = 0.05$, two tail) indicated the following reliable differencies in lick-rate: 32–4>32–32>4–4>4–32. In addition, the analysis indicated an overall effect of drugs, $F(3,24) = 3.81$, $p<0.05$. Subsequent analysis of this term with the lsd procedure indicated that the drug effect was due to a general linear increase in lick-rate as drug dose was increased, with the difference between the saline condition and the 10 mg/kg chloridazepoxide condition being statistically reliable. There was no reliable effect of test session (columns of the latin square), nor were interactions between column and concentration or drug and concentration statistically reliable.

A similar analysis of variance conducted on the data obtained from the deprived animals indicated once again a highly reliable effect of sucrose concentration on lick-rate, $F(3,24) = 92.39$, $p<0.001$. Subsequent analysis with the lsd procedure also again indicated that differences in lick-rate among all four concentration conditions were reliable in the order 32–4>32–32>4–4>4–32.

Contrary to what was found with the ad lib animals, there was no reliable effect of the drug on overall lick-rate ($F<1.00$). There was, however, a reliable effect of test session, $F(3,24) = 3.54$, $p<0.05$. Examination of the column means showed that the lick rate over the last three test sessions was higher than the lick-rate obtained in the first test session, but the only difference that was reliable by the LSD procedure was the difference between the first session and the third test session.

There were no reliable interactions between drug and sucrose concentration condition nor between column and sucrose concentration condition.

Separate analysis of variance comparing positive and negative contrast effects obtained under ad lib and deprivation conditions indicated that neither positive nor negative contrast was reliably influenced by deprivation condition ($F<1.00$ in both cases). However, overall lick-rate was higher in the deprived animals than in the ad lib animals under both positive and negative contrast conditions, $F(1,6) = 8.64$, $p<0.03$, and $F(1,6) = 7.61$, $p<0.04$, respectively.

Latency. The results obtained with the latency measure were generally the same as those obtained with the lick-rate measure. That is, there were reliable positive and negative contrast effects that were not influenced by deprivation condition or by chlordiazepoxide. These results will not be presented in statistical detail.

Although the drug did not influence degree of contrast, it did have an effect on overall latency to respond. In both ad lib and deprived animals the latency ($\log_{10}$ transformation) to switch tubes was shorter under the influence of chlordiazepoxide than under the saline condition, $F(3,24) = 4.78$, $p<0.05$; and $F(3,24) = 7.22$, $p<0.01$, respectively.

Discussion

The principal results of the present experiment were the following: (1) positive and negative contrast effects were obtained in both consummatory and latency measure of behavior; (2) deprived animals showed more consummatory behavior and shorter latencies to switch tubes than ad lib animals, but the deprivation conditions did not materially alter degree of contrast; (3) injections of chlordiazepoxide tended to increase the consummatory behavior of ad lib animals and decrease the latency to switch tubes in both ad lib and deprived animals, however, the chlordiazepoxide injections did not influence the degree of either positive or negative contrast. The effect of the drug on consummatory behavior is consistent with an earlier study showing that chlordiazepoxide increased food intake [27].

Taken together, the results of the three experiments presented in this paper are unfavorable for interpretations of contrast framed in terms of generalization decrement or emotional processes. To recapitulate briefly, a generalization decrement interpretation of contrast applies to negative contrast only, not to positive contrast (as was obtained in all three experiments), and, furthermore, the generalization decrement interpretation of negative contrast implies that such a contrast should diminish as the animals are given repeated experience with the two reward levels [6]. Such a result was not obtained.

An account of contrast in terms of emotional processes would also seem to imply an eventual waning of contrast [12], as well as a diminution of contrast under the influence of chlordiazepoxide or imipramine [5,29]. Again, such a result was not obtained.

Our interpretation of these data is that contrast, as obtained in the present paradigm, is due primarily to the sensory-perceptual consequences of the shift in sucrose solutions. By this we mean that the ingestion of sucrose solutions of different concentrations in close temporal proximity alters the taste of the second solution, much as has been reported in the human literature [3,23]. It is this altered taste itself that leads to the differential consummatory behavior under 32–4 conditions as opposed to 4–4 and 32–32 conditions.

Circumstantial support for this interpretation may be derived from data showing that systematic variations in the ratios of concentrations of the two sucrose solutions presented to rats in the two bottle paradigm leads to variations in the ratios of the rat's intake that follow the power law with an exponent in the range of that found in human psychophysical studies of sweetness judgments [16].

This interpretation does not preclude the occurrence of an emotional or arousal response that may result from the altered taste, but the data appear to be convincing in indicating that the contrast itself is not caused by any such emotional response. We should also reiterate that this interpretation of contrast may be linked to the present contrast paradigm since other, previously cited, studies have found effects of chlordiazepoxide in the successive contrast paradigm. The exact nature of the difference between the two paradigms must await further research.

REFERENCES

1. Adamson, R. Contrast effects and reinforcement. In: *Adaptation-Level Theory,* edited by M. H. Appleby. New York: Academic Press, 1971.
2. Baltzer, V. and L. Weiskrantz. Negative and positive behavioral contrast in the same animals. *Nature* **228:** 581–582, 1970.
3. Bartoshuk, L. M. Water taste in man. *Perception and Psychophysics.* **3:** 69-72, 1968.
4. Bevan, W. The contextual basis of behavior. *Am. Psychol.* **23:** 701–713, 1968.
5. Bloomfield, T. M. Contrast and inhibition in discrimination learning by the pigeon: Analysis through drug effects. *Learn. Motiv.* **3:** 162–178, 1972.
6. Capaldi, E. J. and D. Lynch. Repeated shifts in reward magnitude: Evidence in favor of an associational and absolute (non-contextual) interpretation. *J. exp. Psychol.* **75:** 226–235, 1967.
7. Chechile, R. and H. Fowler. Primary and secondary negative incentive contrast in differential conditioning. *J. exp. Psychol.* **97:** 189–197, 1973.
8. Cleland, E. A., M. Y. Williams and V. DiLollo. Magnitude of negative contrast effect in relation to drive level. *Psychon. Sci.* **15:** 121–122, 1969.
9. Crespi, L. P. Amount of reinforcement and level of performance. *Psychol. Rev.* **51:** 341–357, 1944.
10. Crespi, L. P. Quantitative variation in incentive and performance in the white rat. *Am. J. Psychol.* **55:** 467–517, 1942.
11. Dews, P. B. A. A behavioral output enhancing effect of imipramine in pigeons. *Int. J. Neuropharm.* **1:** 265–272, 1962.
12. Dunham, P. J. Contrasted conditions of reinforcement: A selective critique. *Psychol. Bull.* **69:** 295–315, 1968.
13. Flaherty, C. F. and A. Avdzej. Bidirectional contrast as a function of rate of alternation of two sucrose solutions. *Bull. Psychon. Soc.* **4:** 505–507, 1974.
14. Flaherty, C. F. and J. Largen. Within-subjects positive and negative contrast effect in rats. *J. comp. physiol. Psychol.* **88:** 653–664, 1975.
15. Flaherty, C. F., E. P. Riley and N. E. Spear. Effect of sucrose concentration and goal units on runway behavior in the rat. *Learn. Motiv.* **4:** 163–175, 1973.
16. Flaherty, C. F. and S. Sepanak. Bidirectional contrast as a function of sucrose concentration disparity. Paper presented at the Psychonomic Society Meetings, 1974.

17. Goldman, L., G. D. Coover and S. Levine. Bidirectional effects of reinforcement shifts on pituitary adrenal activity. *Phsyiol. Behav.* **10:** 209–214, 1973.
18. Halliday, M. S. and R. A. Boakes. Behavioral contrast without response rate reduction. *J. exp. Anal. Behav.* **22:** 453–462, 1974.
19. Helson, H. *Adaptation-Level Theory: An Experimental and Systematic Approach to Behavior.* New York: Harper and Row, 1964.
20. Huang, I–N. Successive contrast effects as a function of type and magnitude of reward. *J. exp. Psychol.* **82:** 64–69, 1969.
21. Iversen, S. D. and L. L. Iverson. *Behavioral Pharmacology.* Oxford: Oxford University Press, 1975.
22. Li, J. C. R. *Statistical Inference I.* Ann Arbor: Edwards Brothers, 1964.
23. McBurney, D. H. Gustatory cross adaptation between sweet-tasting compounds. *Percept. Psychophys.* **11:** 225–227, 1972.
24. Mellgren, R. L. Positive and negative contrast effects using delayed reinforcement. *Learn. Motiv.* **3:** 185–193, 1972.
25. Nevin, J. A. Stimulus control. In: *The Study of Behavior: Learning, Motivation, Emotion and Instinct,* edited by J. A. Nevin. Glenview: Scott Foresman, 1973, pp. 115–148.
26. Pert, A. and R. C. Gonzalez. Behavior of the turtle *(Chrysemys picta picta)* in simultaneous, successive, and behavioral contrast situations. *J. comp. physiol. Psychol.* **87:** 526–538, 1974.
27. Randall, L. O., W. Schallek, S. A. Heise, E. P. Keith and R. E. Bagdon. The psychosedative properties of methamino diazepoxide. *J. pharmac. exp. Ther.* **129:** 163–171, 1960.
28. Rosen, A. J., D. H. Glass and J. R. Ison. Amobarbital sodium and instrumental performance changes following reward reduction. *Psychon. Sci.* **9:** 129–130, 1967.
29. Rosen, A. J. and R. E. Tessel. Chlorpromazine, chlordiazepoxide, and incentive shift performance in the rat. *J. comp. physiol. Psychol.* **72:** 257–262, 1970.
30. Scull, J., K. Davies and A. Amsel. Behavioral contrast and frustration effect in multiple and mixed fixed-interval schedules in the rat. *J. comp. physiol. Psychol.* **71:** 478–483, 1970.
31. Terrace, H. S. Errorless discrimination learning: Effects of chlorpromazine and imipramine. *Science* **140:** 318–319, 1963.
32. Valliant, G. E. A comparison of chlorpromazine and imipramine on behavior of the pigeon. *J. Pharmac. exp. ther.* **146:** 377–384, 1964.
33. Vogel, J. R. and K. Principi. Effects of chlordiazepoxide on depressed performance after reward reduction. *Psychopharmacology* **21:** 8–12, 1971.