Journal of Experimental Psychology
1961, Vol. 62, No. 2, 196–199

A CONTRAST EFFECT IN DIFFERENTIAL CONDITIONING [1]

GORDON H. BOWER

Stanford University

Contrary to the interests of parsimony in theory construction, an increasing number of experiments have shown that the reinforcing effect of a given amount of reward is not a static parameter; rather, the conception that emerges from these studies is that the reinforcing effect depends upon the context in which that reward quantity occurs; in particular, it depends upon the range of alternative rewards *S* has received in the experimental situation.

The most direct evidence for this context effect comes from studies of visual discrimination learning. Meyer (1951) and Schrier and Harlow (1956), working with monkeys, and Lawson (1957), working with rats, found that rate of error elimination in a series of visual discrimination problems was not significantly related to the amount of reward when *S* received the same amount (large or small) on every problem. By comparison, if *S* received different amounts of reward for performing correctly on different problems of the learning series, learning rate on a given problem varied directly with the amount of reward for that problem.

These prior studies investigated the context effect in selective learning situations in which the performance measure (percentage of correct responses) presumably reflects the resolution among several competing reaction tendencies. The purpose of the present experiment was to study the context effect in an instrumental learning situation where the presumed relationship between the performance measure (i.e., response speed) and net incentive value is relatively simple. The design of this experiment involved one experimental and two control groups. The experimental (Contrast) *S*s were trained concurrently in two distinct straight runways, with a large reward in one runway (S^+) and a small reward in a different runway (S^-). One control group received a large reward on every trial and a second control group received a small reward on every trial. Asymptotic performance of the Contrast group in S^+ was compared with that of the large reward control group; performance in S^- was compared with that of the small reward control group. A contrast effect would be indicated by significant differences in either or both of these comparisons.

METHOD

Subjects.—The *S*s were 30 male albino rats, approximately 120 days old. They were housed in individual living cages. Taming and adjustment to a 12 gm. feeding diet was carried on for two weeks prior to runway training. The 30 *S*s were randomly assigned to three groups of 10.

Apparatus.—The training apparatus was a double runway similar to that described by Logan, Beier, and Ellis (1955). Two enclosed 5-ft. runways were constructed side by side, the left one painted black and the right one painted white. A single gray startbox adjoined the front end of the apparatus; by closing guillotine doors the entrance to either runway could be blocked. One Standard Electric clock timed the interval from the opening of the startdoor to *S*'s breaking a

[1] The assistance of Charles Hoye in the collection of the data is gratefully acknowledged. This research was supported in part by Research Grant M-3849 from the National Institute of Mental Health of the National Institutes of Health, United States Public Health Service.

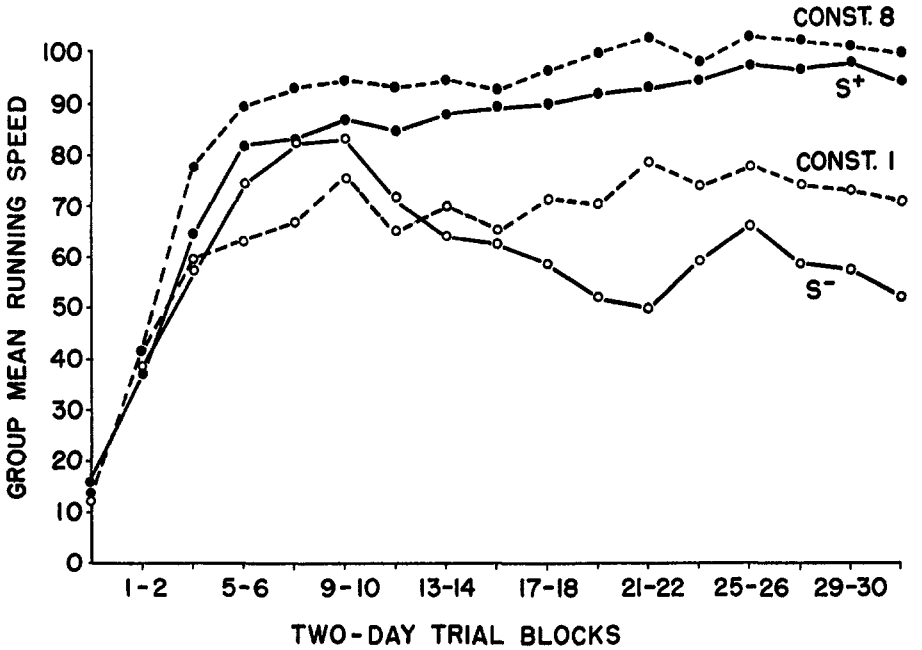

FIG. 1. Group average running speed plotted in blocks of two days. (The dashed curves represent performance of the Constant reward control groups; the solid curves represent performance of the Contrast group in S^+ and in S^-.)

photobeam 6 in. out in either alley (start-time); a second clock recorded the interval from the first photobeam to a second photobeam located 2 in. from the end of the runways (giving running time). The goalboxes, comprising the last 12 in. of the runways, were equipped with guillotine doors which were lowered after *S* interrupted the goalbox photobeam. Food pellets were placed in pill caps secured to the floor at the end of each goalbox. Between trials, *S*s were detained in a 12 × 16 × 5 in. unpainted wooden box where water was always available.

Procedure.—The Contrast *S*s received half of their four daily trials in one runway (S^+) with an eight pellet reward (each pellet weighing 45 mgm.) and the remaining daily trials in the other runway (S^-) with a one pellet reward. For half the *S*s, S^+ was the left-black alley; for the other *S*s, S^+ was the right-white alley. The six possible orders of two S^+ and two S^- trials occurred equally often; the daily order for half the *S*s was randomly selected (e.g., + − − +) and the remaining *S*s had the reverse sequence (− + + −). One control group, Constant 8, received four daily trials each rewarded with eight pellets; the Constant 1 control group received four daily trials with a one pellet reward. Half of each control group was run in the right-white runway and half was run in the left-black runway, a given *S* always running in the same runway. The *S*s were left in the goalbox 15 sec., although these times were a bit longer on the first few trials before *S*s ate promptly.

A total of 32 acquisition days (128 trials) were given, half of these to S^+ for the Contrast group. Each *S* received its four daily trials in alternation with a second *S*; one rested in the detention cage with water available while the other received one trial; then the first *S* was given another trial, and so on until both had had four trials. Therefore, the intertrial interval varied around 1 min. Ten minutes after the day's trials all *S*s were fed 12 gm. minus the amount of food received in the alley.

RESULTS

The results are presented graphically in Fig. 1 which shows group average running speeds plotted in two-day blocks.[2] The dashed curves

[2] Although starting speeds showed the same pattern of results as did running speeds (somewhat amplified, in fact), they are not pre-

represent the Constant groups and the solid curves represent S^+ and S^- speeds for the Contrast group. The curves for the Contrast *S*s show the gradual development of differential behavior to S^+ and S^-, the differentiation being due primarily to the reduction in S^- speeds following the peak performance on Days 7-10. During these peak days, Days 7–10, performance in S^- was significantly faster than performance of the Constant 1 control group ($t = 2.00$, $df = 18$, $P = .06$, two-tailed test); over the same block of trials, performance in S^+ was significantly below that of the Constant 8 control group ($t = 2.84$, $P = .02$). By the end of training (Days 27–32) performance in S^- had fallen to a level significantly below that of the Constant 1 group ($t = 2.48$, $P = .03$), thus showing an ultimate contrast effect in S^-. At the termination of training, performance in S^+ had increased to about the level of the Constant 8 group ($t = 1.19$ for the difference over Days 27–32); both of these speed averages differed from that of the Constant 1 *S*s at well beyond the .01 level.

Discussion

These results have shown that the net incentive produced by a small reward is diminished when that reward occurs in a situation where *S* sometimes receives larger rewards. One question raised but not answered in this study is whether this reduced incentive value is a relatively permanent effect; conceivably, after more extended discrimination training, performance in S^- might recover to the level displayed by the Constant 1 control group. Observations from two other studies have indicated that a similar downward contrast effect appears even when the reward in S^- is zero. For example, Logan (1960) has reported that when trials are sufficiently spaced, rats will run down a runway at a slow but moderate speed although they have never been rewarded in such a situation; in comparison, in a discrimination experiment (Bower & Trapold, 1959) it was observed that when rats were rewarded when run in S^+ on half their trials, they developed an active avoidance of the nonrewarded goalbox on S^- trials. Thus, the acceptability of even "no reward" appears to be influenced by the alternative rewards the *S* receives in the experimental situation.

These data provide no evidence for an "upward" contrast effect (i.e., an S^+ performance superior to that of the large reward group); in fact, the data show S^+ performance to be slightly below that of the Constant 8 group. However, it might be argued that the use of a very large reward (eight pellets) precluded the appearance of the upward contrast effect because of the ceiling inherent in the speed measure; conceivably, the effect might appear at lower reward values and this possibility remains to be tested.

One may note that the pattern of contrast effects found here agrees with the findings of studies involving shifts in reward quantity. Reduction in reward quantity frequently leads to a momentary depression in performance of the shifted group to below that of a constant small reward group; in comparison, if sufficient preshift training has been given, increases in reward quantity do not produce a temporary "elation" of the shifted group to above the performance of a constant large reward group.

It is suggested that "downward" contrast effects like those reported here may be understood in terms of a frustration construct such as Amsel (1958) has proposed. Amsel treated only the case

sented since they are probably biased in favor of faster starting speeds for the control groups. The control *S*s always ran in the same runway (e.g., left) and undoubtedly learned favorable orienting behaviors in the startbox; the Contrast *S*s, running equally often to the right and left runways, could not learn such favorable preparatory behavior. This differential preparatory factor is quite unlikely to have affected the running times which were recorded after the response was well under way.

where frustration is elicited by nonreward after sufficient prior rewards have resulted in the development within the situation of a stable anticipatory goal response (r_g). To handle the present data, his hypothesis must be extended to include within the class of frustrating events the occurrence of a reward that is smaller than that appropriate to the ongoing r_g amplitude. More direct evidence bearing on such an extension has been reported elsewhere (Bower & Stocks, 1960).

Applying this analysis to the present experiment, the lowered performance in S^- is considered to result from a conflict between anticipation of reward (r_g) and the anticipation of frustration in the S^- goalbox. Frustration is expected to be elicited in the S^- goalbox during the intermediate stages of discrimination training when the large amplitude r_g established in S^+ occurs in S^- through stimulus generalization. It may be noted that this analysis does not imply an upward contrast effect in S^+ and is thus consistent with that part of the data.

Summary

This study investigated the effect on runway performance of rats of giving contrasting amounts of reward in two concurrent learning situations. Rats in the Contrast group received a large reward when run in one alley (S^+) and a small reward when run in a different alley (S^-), the two types of trials occurring in random alternation. Performance in S^+ and S^- was compared with that of two control groups, one receiving a large reward and one receiving a small reward on every trial. Asymptotic performance of the Contrast group in S^- was inferior to that of the small reward control group, whereas performance in S^+ was slightly but not significantly lower than that of the large reward control group. Thus, the effectiveness of a small reward is diminished when it occurrs in a context where *S* sometimes receives larger rewards. These results were interpreted in terms of frustration elicited by the small reward when *S* expects a large reward.

References

Amsel, A. The role of frustrative nonreward in noncontinuous reward situations. *Psychol. Bull.*, 1958, **55**, 102–119.

Bower, G. H., & Stocks, D. Graded frustration effect as a function of graded reductions in reward. Paper read at meeting of the Psychonomic Society, Chicago, 1960.

Bower, G. H., & Trapold, M. A. Magnitude of reward and performance in a single presentation discrimination. *J. comp. physiol. Psychol.*, 1959, **52**, 727–729.

Lawson, R. Brightness discrimination performance and secondary reward strength as a function of primary reward amount. *J. comp. physiol. Psychol.*, 1957, **50**, 35–39.

Logan, F. A. *Incentive.* New Haven: Yale Univer. Press, 1960.

Logan, F. A., Beier, E. M., & Ellis, R. A. The effect of varied reinforcement on speed of locomotion. *J. exp. Psychol.*, 1955, **49**, 260–266.

Meyer, D. R. The effects of differential reward on discrimination reversal learning by monkeys. *J. exp. Psychol.*, 1951, **41**, 268–274.

Schrier, A. M., & Harlow, H. F. Effect of amount of incentive on discrimination learning by monkeys. *J. comp. physiol. Psychol.*, 1956, **49**, 117–122.

(Received June 24, 1960)