high current levels is clearly conditional upon the extent of damage to the brain caused by the stimulation. Histology showed that gliosis at the electrode tips was comparable to that found in rats following a similar history of stimulation at low current intensities. Lesion attributable to stimulation appeared to be restricted to a small area around the electrode tip.

The pattern of responding at the various current levels may be seen in the cumulative records presented in Fig. 3. The cumulative records show bursts of high rate of responding at all current levels. These bursts are separated by periods of responding at a very low rate. The periods of low rate are long and frequent at low current levels and decrease in length and frequency as current level increases. This was characteristic of the cumulative records of all three birds. During bursts of high rate, stimulation was often continuous for long periods, since every peck produced a 0.5-sec stimulation. This suggested the possibility that responding was maintained primarily by continuous stimulation and that responding might not be maintained in a situation where prolonged stimulation was not possible. This was investigated in a subsequent study where it was found that very high, uniform rates of responding developed on a fixed-ratio schedule where stimulation followed every tenth response. On this schedule, continuous stimulation was possible only if rates exceeded 20 per sec. Such a condition was in fact not

attained, indicating that prolonged stimulation was not an essential factor.

REFERENCES

- BOYD, E. S., & GARDNER, L. C. Positive and negative reinforcement from intracranial stimulation of a teleost. *Science*, 1962, 136, 648-649.
- HAWKINS, T. D., & PLISKOFF, S. S. Brain stimulation intensity, rate of self-stimulation, and reinforcement strength: An analysis through chaining. *Journal of the Experimental Analysis of Behavior*, 1964, 7, 285-288.
- HEATH, R. G., & MICKLE, W. A. Evaluation of seven years experience with depth electrode studies in human patients. In E. R. Ramsey and D. S. O'Doherty (Eds.), *Electrical studies on the unanesthetized brain*. New York: Paul B. Moebier, 1960.
- KARTEN, H. J., & HODOS, W. *A stereotaxic atlas of the brain of the pigeon*. Baltimore: Johns Hopkins Press, 1967.
- MACPHAIL, E. M. Self-stimulation in pigeons: The problem of "priming." *Psychonomic Science*, 1966, 5, 7-8.
- MACPHAIL, E. M. Positive and negative reinforcement from intracranial stimulation in pigeons. *Nature*, 1967, 213, 947-948.
- MILLER, N. E., & DICARA, L. Instrumental learning of heart-rate changes in curarized rats: Shaping and specificity to discriminative stimulus. *Journal of Comparative & Physiological Psychology*, 1967, 63, 12-19.
- OLDS, J., & MILNER, P. Positive reinforcement produced by electrical stimulation of the septal area and other regions of rat brain. *Journal of Comparative & Physiological Psychology*, 1954, 47, 419-427.
- OLDS, J. Self-stimulation of the brain. *Science*, 1958, 127, 315-324.
- TROWILL, J. A. Instrumental conditioning of the heart rate in the curarized rat. *Journal of Comparative & Physiological Psychology*, 1967, 63, 7-11.

more generally used today. In addition to the PCE, Crespi and Zeaman also reported the reciprocal effect, i.e., rats trained at a large reward and subsequently shifted to a small reward tended to show a "depression" or a negative-contrast effect (NCE) by "undershooting" the estimated performance of a consistently small rewarded group.

In more recent years both the PCE and the NCE have proved to be reasonably reliable phenomena in the free-operant situation (Reynolds, 1961). Nevertheless, two recent reviews of the literature, dealing mainly with the simple discrete-trial instrumental or selective learning situations, have suggested that the NCE frequently occurs in such situations but the symmetrical finding of a PCE seldom occurs (Black, 1968; Dunham, 1968). One possible explanation of the failure to find the PCE is the "ceiling hypothesis" suggested by Bower (1961). According to that view, the PCE might be prevented when the performance of a large-reward control group is at or near some physical limit. The absence of the PCE might be seen, then, not as a matter of behavioral principles, but as an artifact of experimental design.

The purpose of the present experiment was to test this hypothesis by varying the number of small rewarded trials (0, 5, 10, 15) prior to a shift to large reward. Two other experiments have reported similar designs but, unfortunately, their experiments were conducted for other reasons, and the shifts from small to large reward occurred well after the consistently large rewarded group had reached asymptote (Ashida & Birch, 1964; Birch & Valle, 1967).

SUBJECTS

The Ss were 72 experimentally naive male albino rats of the Sprague-Dawley strain, selected from the colony at Southern Methodist University. Ss were approximately 80 days old at the outset of training.

APPARATUS

The apparatus, a black plastic Hunter small-animal runway, was 74 in. long, 3.25 in. wide, and 5 in. high. The entire length was covered with a removable plastic top and the floor consisted of .13-in. grids spaced .5 in. apart. The final 12-in. section served as a goalbox and was separated from the remainder of the runway by a guillotine door. A stainless steel food cup was mounted approximately 1.5 in. above the grid floor and at the extreme distal end of the goalbox. Response times were measured over three sections of the runway by a system of photoelectric relays wired to control Standard Electric clocks (.01-sec units).

A test of the "ceiling effect" hypothesis of positive contrast*

PATRICK E. CAMPBELL, CHARLES M. CRUMBAUGH,
STEPHEN B. KNOUSE, and M. EMILY SNODGRASS†
Southern Methodist University, Dallas, Tex. 75222

Seventy-two rats were given 0, 5, 10, or 15 small rewarded trials prior to being shifted to large reward for the remainder of 45 trials. Each of the groups which experienced an upward shift in reward magnitude rapidly approximated the performance of a consistently large rewarded control group, and in no case was a positive contrast effect observed. The performance curves for all the groups remained interlaced for a rather protracted period of asymptotic training. The results were discussed in terms of their relevance to the "ceiling effect" hypothesis of the absence of positive contrast.

*This research was partially supported by Grant No. GU-3093 from the National Science Foundation to Southern Methodist University. The study was conducted according to the APA statement of "Principles for the care and use of animals," June 26, 1968. We would like to acknowledge the assistance of Ken Husa and Steve Prestwood for matters relating to computer analysis of the data. Reprints may be obtained from Patrick E. Campbell, Department of Psychology, Southern Methodist University, Dallas, Tex. 75222.

†Now at the State University of New York at Stony Brook.

The effect of a given amount of reward sometimes depends upon the "context" in which the reward occurs. For example, both Crespi (1944) and Zeaman (1949) reported that rats trained at a small reward and then shifted to a large reward tended to "overshoot" the performance level estimated for animals exposed only to the larger reward. Although this phenomenon was originally termed an "elation effect," the term "positive-contrast effect" (PCE) is

Fig. 1. Mean goal speed for each experimental condition in blocks of two trials.

Start times were measured from the time S was placed into the starting area until S had traversed a 10-in. section. Run and goal times were measured over the next 39 in. and the final 16-in. sections of the runway. The terminal goal measure photocell was located 3 in. in front of the goal cup.

DESIGN AND PROCEDURE

During 10 days of pretraining, Ss were handled, trained to eat .045-g Noyes pellets (to be used as rewards), and adapted to the runway. During this period Ss were reduced to approximately 85% of free-feeding body weight be controlled feeding given at least 15 min after their daily training. Following pretraining, the Ss were divided into four groups (N=18) and given 45 runway trials at one

trial a day. One of the groups (0-45) received large reward (24 pellets) on all 45 trials. The remaining groups received 5 (5-40), 10 (10-35), or 15 (15-30) small rewarded trials (2 pellets) prior to being shifted to large reward.

The Ss were run in two replications of 36 animals each. Within each replication, the animals were run in squads of four with

one S from each treatment represented. On all trials Ss were confined in the goalbox until the reward had been consumed.

RESULTS

Response times were converted to comparable speed units (inches/second) and averaged over blocks of two trials. Although the individual alley measures showed similar results, the goal measure contained the least amount of within-S variability and is shown in Fig. 1. The arrows in the figure indicate the first trial block in which the shift to large reward could be revealed in the data. Note that only Group 5 showed the slightest indication of a contrast effect. Furthermore, the speed curves for all of the groups remained interlaced for a considerable period following the shift to large reward.

Analyses of variance on these data revealed, of course, that blocks were highly significant in each measure ($F = 117.56, 240.29, 228.12$, for start, run, and goal, respectively; $df = 22/1408, p < .001$). Groups, however, did not show a significant main effect ($F = .80, .71, 1.86$; $df = 3/64, p > .05$) but showed a reliable interaction with blocks in the run and goal

measure ($F = 1.15, 1.37, 2.97$; $df = 66/1408, p < .05$). A simple contrast F test showed that the suggestion of contrast in Group 5 was not statistically reliable ($F < 1.0$).

DISCUSSION

It is apparent that a positive effect did not occur in these data even though the problems of a so-called "ceiling effect" were minimized. It seems, then, that the theories implying asymmetry in contrast effects (Amsel, 1962; Capaldi, 1967) are more justified than symmetrical theories such as Helson's (1964).

REFERENCES

- AMSEL, A. Frustrative nonreward in partial reinforcement and discrimination learning: Some recent history and a theoretical extension. *Psychological Review*, 1962, 69, 306-328.
- ASHIDA, S., & BIRCH, D. The effects of incentive shift as a function of training. *Psychonomic Science*, 1964, 1, 201-202.
- BIRCH, D., & VALLE, F. P. Resistance to extinction in the runway following a shift from small to large reward. *Journal of Comparative & Physiological Psychology*, 1967, 63, 50-53.
- BLACK, R. W. Shifts in magnitude of reward and contrast effects in instrumental and selective learning: A reinterpretation. *Psychological Review*, 1968, 75, 114-126.
- BOWER, G. H. A contrast effect in differential conditioning. *Journal of Experimental Psychology*, 1961, 62, 196-199.
- CAPALDI, E. J. A sequential hypothesis of instrumental learning. In K. W. Spence and J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory*. Vol. 1. New York: Academic Press, 1967, Pp. 67-156.
- CRESPI, L. P. Amount of reinforcement and level of performance. *Psychological Review*, 1944, 51, 341-357.
- DUNHAM, P. J. Contrasted conditions of reinforcement: A selective critique. *Psychological Bulletin*, 1968, 69, 295-315.
- HELSON, H. H. *Adaptation level theory*. New York: Harper & Row, 1964.
- REYNOLDS, G. S. Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 55-71.
- ZEAMAN, D. Response latency as a function of amount of reinforcement. *Journal of Experimental Psychology*, 1949, 39, 466-483.