induction of tonic immobility in animals. Journal of Comparative & Physiological Psychology, 1950, 43, 99-111.
RATNER, S. C. Comparative aspects of hypnosis. In J. E. Gordon (Ed.), *Handbook of clinical and experimental hypnosis*. New York: Macmillan, 1967. Pp. 550-587.
RATNER, S. C., & THOMPSON, R. W. Immobility reactions (fear) of domestic fowl as a function of age and prior experiences. Animal Behaviour, 1960, 8, 186-191.
SALZEN, E. A. Imprinting and the immobility reactions of domestic fowl. Animal Behaviour, 1963, 11, 66-71.

NOTES

1. Gallup, G. G., Jr., Cummings, W. H., & Nash, R. F. The experimenter as an independent variable in studies of animal hypnosis. Submitted for publication.

2. Gallup, G. G., Jr., Nash, R. F., Potter, R. J., & Donegan, N. H. The effect of varying conditions of fear on immobility reactions in domestic chickens *(Gallus gallus)*. Submitted for publication.

Repeated acquisition as a behavioral baseline*

DONALD M. THOMPSON
Georgetown University Schools of Medicine and Dentistry, Washington, D.C. 20007

The Boren (1963) technique for studying variables affecting acquisition with an individual-S design was modified and used with pigeons. The sensitivity and reversibility of the steady-state baseline were demonstrated by temporarily removing the different stimuli correlated with the different members of the chain. This "tandem" probe produced a substantial increase in the number of learning errors.

Boren (1963) reported a technique for studying variables affecting acquisition using an individual-S design. Briefly, the learning situation was as follows: Each S (rhesus monkey) worked for food reinforcement in a chamber containing 12 levers arranged in four groups of three. "For each session the monkey's task was to learn a new four-response chain by pressing the correct lever in each group. A stable pattern of learning resulted, and the number of errors reached a steady state from session to session [Boren & Devine, 1968, p. 651]." This steady state of repeated acquisition was then used as a baseline to study the effects of timeout and "instructional" stimuli.

In the present research the Boren technique was modified and used with pigeons. It was hoped that the modification would keep the baseline procedures functionally equivalent but permit more flexibility in varying the difficulty of the learning task, e.g., increasing chain length. More specifically, the four groups of three response keys in the chain were differentiated by color rather than by position. The steady state of repeated acquisition of such chains was then used as a baseline to study the effect of a "tandem" probe.

SUBJECTS

The Ss were two 5-year-old male experimentally naive White Carneaux pigeons. They were maintained at 80% of free-feeding weight. Water was always available in the home cages.

APPARATUS

The apparatus was a standard three-key pigeon chamber (LVE Model 1519B) and connecting automatic control equipment. The scheduling of events was accomplished by means of timers, steppers, and associated relay circuitry; the recording by counters and a 20-pen event recorder. White noise was continuously present in the chamber to mask extraneous sounds.

PROCEDURE

Throughout the following procedures the primary reinforcer was food (5-sec access to mixed grain). Presentation of the food magazine was accompanied by the offset of the key lights, the offset of the houselight (which was on only during magazine training and shaping), and the onset of the magazine light. Each session terminated after 60 food presentations. A "blackout" (all lights off) of variable duration preceded and followed each session. With few exceptions, there were six daily sessions a week.

Preliminary training included magazine training, shaping of key pecking, and reinforcing pecks on each of the three keys, which were transilluminated with white lights. Then the birds were trained to make a chain of responses. At first, food presentation was contingent upon a chain of two responses. The three keys were transilluminated with red lights, and a peck on any key changed the lights to white. Then, when the bird pecked any of the white keys, it received food, after which the red key lights reappeared, etc. In the same way the chain was gradually extended to include the two other colors. The FR 1 (CRF) food contingency was in effect for the entire chain; i.e., the bird pecked the keys four times, once in the presence of the yellow, green, red, and white lights, with the final peck followed by access to grain. This preliminary training required four sessions.

Baseline

The fifth session was the first baseline session. Now responses on only specified keys from each set of colors led to food presentation, e.g., keys yellow: left correct; keys green: right correct; keys red: center correct; keys white: right correct; food. The same sequence (LRCR) was repeated throughout the session. When the pigeon pecked an incorrect key (a key not included in the above sequence), the error was followed by a 15-sec time-out. During the time-out, the key lights were off and food was unavailable. An error did not reset the sequence, i.e., the key lights after the time-out were the same color as before the time-out. For convenience, each completion of the sequence was considered a "trial," even though there was no "intertrial interval" as conventionally defined. The errors made during a trial were recorded separately for each color, and their reduction during a 60-trial session was taken as an index of the rate of learning.

The sequence of correct key positions was changed from session to session. Following Boren, the sequences were carefully selected to be equivalent in several ways, and there were restrictions on their ordering across sessions. First, a correct color position in one session was not repeated in the following session. Second, simple orders, such as the left key in each group of colors, were avoided. In fact, in the present research, adjacent positions in each sequence were always different, although each position occurred at least once. Third, within a set of six sequences, each key position appeared equally often (twice) in each color. An example of a typical set of six sequences is as follows: LRCR, CLRL, LRLC, RCRL, CLCR, RCLC; the order of the associated colors was always the same: yellow, green, red, white (food).

Probe

When the rate of learning had stabilized from session to session (40-60 days), a temporary change in procedure ("probe") was introduced. Different colored key

*This research was supported in part by Public Health Service Grants FR 5360 and FR 5306.

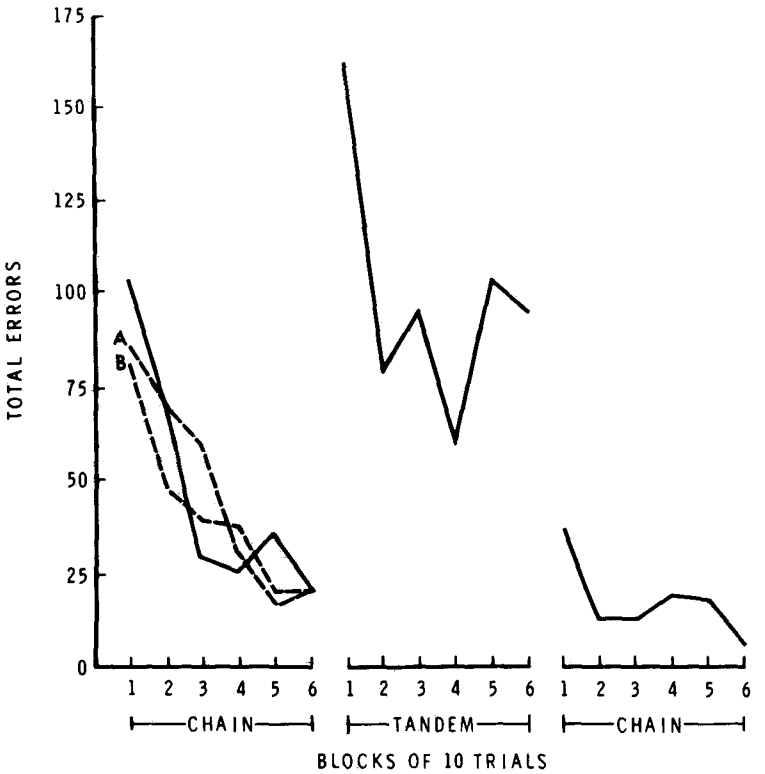

Fig. 1. Learning curves for an individual S during chained and tandem response sequences. Each curve represents one 60-trial session. See text for details.

lights were no longer associated with a sequence; when the key lights were on, they were always white. (There was a momentary dimming of the lights when the sequence advanced.) Such a situation, in which a single reinforcement is contingent upon the completion of four behavioral requirements in succession without correlated stimuli, can be termed a "tandem" sequence (cf. Ferster & Skinner, 1957). In the chain procedure the four colored lights indicated specifically the four different members of the chain. With the tandem procedure the white lights removed this cue so that the birds had only serial position as a cue for pecking the correct keys. This tandem sequence was in effect for 60 trials, which began 5 min after the corresponding chained sequence (a regular baseline session). To check on possible satiation effects, an additional 60-trial session with the same chained sequence began 5 min after the tandem session. The pigeons were moved to their home cages during the 5-min intersession intervals, thereby permitting the change to and from the tandem condition (the colored caps on the key lights were removed and replaced). On the day following the probe, the baseline procedure was reinstated.

RESULTS AND DISCUSSION

The solid line in the left section of Fig. 1 shows one S's learning curve for the baseline session (No. 60) that preceded the probe. The learning curves for the baseline session before (B) this one and the baseline session after (A) it are shown for comparison (dashed lines) to indicate the minimum variability obtained once the baseline of repeated acquisition had reached steady state[1] as well as the recovery of the baseline. It should be noted that although the errors showed a systematic decrease during each baseline session, the lowest level of errors was still somewhat above zero (cf. Boren & Devine, 1968). However, there was no evidence that these errors represented "superstitious" responses within the reinforced chain (cf. Boren, 1969).

The center section of Fig. 1 shows the effect of the tandem probe. As can be seen, there was a substantial overall increase above baseline in the number of errors made, even though the sequence was identical in both cases. In fact, the accuracy at the end of the tandem session was about the same as the accuracy at the beginning of the previous chained session. The sharp decrease in errors during the first 20 trials of the tandem session may indicate some learning of the three-key sequence on the basis of serial position alone (cf. Sidman & Rosenberger, 1967).

The right section of Fig. 1 shows the effect of reinstating the chained sequence. In general, the trend of error levels during this session appears to be a continuation of the learning curve from the previous chained session, with an asymptote near zero. These error levels also suggest that the impaired accuracy under the tandem condition was not due to a satiation effect. This implies that there were, in fact, important discriminative and/or reinforcing effects of the stimulus changes associated with the chained sequence. In general, the described effects of introducing the tandem probe and reinstating the chain were replicated using a different sequence with the other S when its own steady-state baseline was used as the reference point.

An analysis was made of the distribution of errors across the four serial positions in the sequence for the baseline, probe, and reinstatement sessions. For both Ss, fewer errors occurred at the beginning and end than at the middle positions under both the chained and tandem conditions. This effect was more pronounced under the tandem condition. In fact, the overall increase in errors associated with the tandem condition (Fig. 1) was largely the result of increased errors made in the middle positions in the sequence. It should be emphasized, however, that this inverted-U-shaped error distribution was not consistently found in other sessions involving different sequences. There was great variability in the error distributions, even though the baseline had stabilized in terms of learning curves (Fig. 1). Since Boren (personal communication) has made the same observation with monkeys under similar conditions, it may be that error distributions are sequence specific.

Repeated acquisition as a behavioral baseline would seem applicable to the study of a wide variety of variables that influence learning. It is currently being used in this laboratory to assess the effects of various drugs on learning.

REFERENCES

BOREN, J. J. Repeated acquisition of new behavioral chains. American Psychologist, 1963, 17, 421. (Abstract)

BOREN, J. J. Some variables affecting the superstitious chaining of responses. Journal of the Experimental Analysis of Behavior, 1969, 12, 959-969.

BOREN, J. J., & DEVINE, D. D. The repeated acquisition of behavioral chains. Journal of the Experimental Analysis of Behavior, 1968, 11, 651-660.

FERSTER, C. B., & SKINNER, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957.

SIDMAN, M., & ROSENBERGER, P. B. Several methods for teaching serial position sequences to monkeys. Journal of the Experimental Analysis of Behavior, 1967, 10, 467-478.

NOTE

1. The transition to this steady state ("learning to learn") and further details about the characteristics of the steady state itself will be described in a subsequent report.