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Durability of Secondary Reinforcement as a Function of Manipulations in the Training and Testing Situations

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DURABILITY OF SECONDARY REINFORCEMENT
AS A FUNCTION OF
MANIPULATIONS IN THE TRAINING AND TESTING SITUATIONS

BY
LEE E. DOERRIES

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
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IN
PSYCHOLOGY

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Two experiments studied durability of secondary reinforcement as a function of manipulations in the training (Experiment I), and training and testing situations (Experiment II). In Experiment I, a total of 40 rats were trained on a single or four different tasks over four consecutive days. Rats received 120 pairings of white noise and food in either a simultaneous or backward conditioning procedure. Testing occurred on a new learning task (lever box) one week following the end of training. Two bars, one of which was consequted with white noise, the other having no consequence, were present during testing. The results showed that the simultaneous conditioning procedure was an efficient method for establishing white noise as a conditioned reinforcer when tested in a new learning paradigm. The backward conditioning control performed consistently at a low operant level of bar press responding. The hypothesis that animals trained on multiple tasks would emit more responses during testing than animals trained on a single task was not supported.

Experiment II repeated the conditions studied in Experiment I but omitted the backward conditioning control. A total of 160 animals were trained on one or four different tasks. Testing occurred either 0-, 1-, 2-, or 4- weeks following the end of training. Test sessions were either proportionately distributed over the four delay conditions (four 15 min. sessions) or were massed for one 60 min. session 0-, 1-, 2-, or 4- weeks following the end of training. This design produced 16 experimental conditions with 10 animals assigned to each condition. The results of Experiment II confirm the findings reported in Experiment I. Simultaneous conditioning was an efficient procedure for establishing a durable secondary reinforcer. Training on multiple tasks failed to increase the number of responses made in testing over response rates of animals that received training on a single task. A significant interaction resulted between 0- and 1- week for subjects tested under proportionately distributed trials. Bar pressing of subjects tested under massed conditions had extinguished at the end of the 60 min. test. Rats tested under distributed conditions 0- to 1-week following the end of training, continued to respond at high levels at the end of the fourth 15 min. session.

The results indicate that the type of test (massed or proportionately distributed) is a critical factor in assessing strength of secondary reinforcement. The response rates of rats tested under proportionately distributed trials (N=80) showed significantly less loss of original learning than animals tested under massed conditions. For distributed test subjects, extinction of the new learning response occurred on the final 15 min. distributed trial, two weeks following the end of training. The results indicate that durable secondary reinforcement can be reliably demonstrated without presenting primary reinforcement in the test situation. The sizable secondary reinforcement effects observed in the present study should renew interest in the new learning paradigm as an effective procedure for assessing the strength of secondary reinforcement.

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To my friend Bill

To Nelson and Dave, who by example and friendship
have given more than I can hope to repay

To Denyse, whose love sustained me throughout the
preparation of this manuscript.

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Observation indicates that common secondary reinforcers such as pleasant words, grades, and money have a durable quality which may be based on a long-term history of conditioning. This durability may occur as a function of past experience in which an initially neutral stimulus was often paired with primary reinforcement. During this conditioning process, which begins at birth and continues through adulthood, a single conditioned stimulus, e.g. a smile, can be paired with a number of primary reinforcers, under varying levels of drive, and different schedules of reinforcement. Without knowing the necessary and sufficient conditions for establishing a secondary reinforcer, most investigators have assumed that durability of secondary reinforcement is a product of the conditioning process described above (Keller and Schoenfeld, 1950; Miller, 1951; Myers, 1958; Kimble, 1961; Kelleher and Gollub, 1962; Wike, 1966; and Hendry, 1969). These authors make the assumption that durable secondary reinforcement may result when: (1) the conditioning is extended over a long period of time; (2) the neutral stimulus has been paired with a number of different primary reinforcers (Skinner, 1953); and (3) the training sessions have been presented on an irregular

schedule (McClelland, 1951; McClelland and McGown, 1953). It is interesting to note that each of these variables has its effect during the training phase.

In making the assumption that durability is established during training, most investigators have concentrated on manipulating variables associated with the original conditioning or training procedure, and neglected the investigation of durability as a function of the extinction and reconditioning procedures which test the effectiveness of a stimulus as a conditioned reinforcer (Hendry, 1969).

If the durability of a secondary reinforcer is a product of the conditioning process, this process must be considered continuous, as it does not end with original learning. By incorporating a broad definition of "conditioning process", it is possible that the effectiveness of a secondary reinforcer is maintained by infrequent repairing with primary reinforcement once initial learning has occurred. This consideration suggested to Wike (1966) the need for a more thorough investigation of the role of reconditioning in maintenance of secondary reward values.

An additional factor which may be operating to convey the impression of durability of secondary rein-

forcement is that tests for secondary reinforcement in real life are usually widely distributed in time. However, laboratory paradigms have commonly tested for durability of secondary reinforcement immediately following training and under conditions of massed extinction. Perhaps the distribution of extinction or new learning trials over a long period of time enhances the apparent durability of secondary reinforcement.

While the previous discussion has considered possible variables which may operate in the establishment of durable secondary reinforcers, the phenomenon is poorly understood and has not been satisfactorily demonstrated in a laboratory study. The present experiments empirically study the durability of secondary reinforcement as a function of manipulations in both the training and testing situations.

Hypotheses and Independent Variables

The present study departs from previous investigations in three important ways and the hypotheses are derived from these departures.

1. Training conditions pair the same neutral stimulus with the same primary reinforcer in a number of different

tasks rather than conditioning with a single task. Most investigations conducted to date have studied secondary reinforcement in a single task situation (Wike, 1966), while varying such conditions as drive, drive level, schedule and amount of reinforcement. It was hypothesized that rats trained with the same primary and secondary reinforcement in a number of different tasks would demonstrate higher response rates during testing (new learning) than animals trained on a single task. This hypothesis is based on the assumption that the acquisition of a new response which is reinforced by the formerly neutral stimulus, will occur faster for subjects who have experienced the neutral stimulus in a number of different stimulus and response situations during training.

2. In most previous investigations, extinction tests have been used to assess the durability of the conditioned reinforcer (Wike, 1966). Such tests involve training and testing on the same task. In the present study, strength of secondary reinforcement was tested in a new learning paradigm under both massed and proportionately distributed acquisition procedures. It should be noted that the new learning paradigm involves acquisition of a new response which occurs as a function

of that response being consequted with the conditioned stimulus. Since the conditioned stimulus is used as a secondary reinforcer and is no longer paired with primary reinforcement, its reinforcing value should eventually be reduced, thus leading to extinction of the newly learned response. Zimmerman (1957) showed that in an extinction procedure, distributed extinction trials facilitated the maintenance of a response over time. Reynolds, et. al. (1961) demonstrated the advantage of distributing test (acquisition) trials in a new learning paradigm. In the present study it was hypothesized that subjects tested under distributed acquisition trials would show a higher response rate than subjects tested under massed acquisition trials.

3. In the present study, the time of testing for secondary reinforcement following initial training, was varied over a four week period. This procedural innovation appears in sharp contrast to the 24 to 48 hour delay of testing which occurs in most studies reported in the literature (Henry, 1969). It was hypothesized that the strength of the secondary reinforcement would decrease over time from original training as a function of the increasing retention interval. Since no work has been published on the effects of long training-test delays on strength of

secondary reinforcement, no specific hypotheses were formulated.

4. A further hypothesis regarding the combination of the above three variables was made. It was expected that strength of secondary reinforcement would be greatest under multiple task training, and distributed acquisition trials, when tested immediately following training.

Additional Variables Possibly Influencing Strength of Secondary Reinforcement

Two previously studied variables which have been thought to affect the strength of secondary reinforcement deserve mention. Studies investigating the maintenance of response strength by a generalized conditioned reinforcer (Skinner, 1953; Wike and McNamara, 1955; Wike and Barrientos, 1958; Kanfer and Matarazzo, 1959; Kanfer, 1960; Wunderlich, 1961; and Ferster and DeMyer, 1962) have shown that secondary reinforcers which have been conditioned on the basis of more than one primary reinforcer are stronger than or equal to, simple secondary reinforcers (those paired with only one primary reinforcer). The differences in response strength between the two types of secondary reinforcers are small, partly dependent upon the type of drive which is in effect at the time

of testing, and they do not approach statistical significance (Wike, 1966). Based on these facts, the author decided not to manipulate primary reinforcement in the present study.

Partial primary reinforcement during training is a second variable which might facilitate the maintenance of a response during testing. The evidence of recent experimentation clearly indicates that in an absolute training situation (one which involves no discrimination) partial primary reinforcement preceded by secondary reinforcement produces a higher response rate than continuous primary reinforcement (Saltzman, 1949; D'Amato, et. al., 1958; Klein, 1959; Myers, 1960; Boyle, 1961; Armus and Garlich, 1961; and McNamara and Paze, 1962). In discrimination learning (differential training procedure), higher response rates are observed to stimuli associated with continuous primary reinforcement than to stimuli associated with partial reinforcement. Training conditions in the present study used both absolute and differential training methods. Because of the difficulty in controlling for the effects of partial and continuous reinforcement, only continuous primary reinforcement was used.

Paradigms for Testing Durability of Secondary Reinforcement.

Three models are currently used for testing secondary reinforcement. These include tests of extinction, chained operants, and new learning.

Most investigators have assessed the strength of secondary reinforcers using extinction tests which involve the same task and response during the initial training phase and the subsequent extinction period. The strength of secondary reinforcement is measured by time or trials to extinction. Interpretation is difficult in this model because the stimulus conditions change for the various control groups from the training to the testing stage due to the removal of the primary reinforcer in the test situation. Thus, in extinction models, stimulus generalization decrement (Myers, 1958) can explain the higher response level of the group receiving the secondary reinforcer.

A few studies have been conducted using the concurrent operant and chained schedule models (Miles, 1956; Ferster and Skinner, 1957; Kelleher and Fry, 1962; Kelleher and Gollub, 1962; Marx and Knarr, 1963; and Zimmerman, 1969). The major characteristic of the

chained schedule model is that secondary reinforcement is always contingent upon the subject's previous response in the chain which was consequted with primary reinforcement. Since primary reinforcement is always present in the chain, proponents of the model argue that the effects of secondary reinforcement are not confounded by the withdrawal of primary reinforcement, as is true with learning and extinction tests (Wike, 1966; Hendry, 1969).

Herrnstein, (1964) reversed this argument by suggesting that in the chained operant model, "the effects of secondary reinforcement are confounded by primary reinforcement." Disregarding this theoretical dispute, the chained operant model was not considered an appropriate paradigm for the present research because the current investigation was interested in testing durability of secondary reinforcement in the absence of primary reinforcement.

In the learning model, training occurs on one or more tasks in which a neutral stimulus (e.g., a tone) follows a response which in turn is followed by a primary reinforcer. After a specified number of pairings the strength of the conditioned reinforcer is tested using it as the reinforcer during the acquisition of

a different task. Depending on its contingent or non-contingent relationship to the primary reinforcement during training, the secondary reinforcer will act differentially to strengthen the response used during testing.

One criticism common to both extinction and new learning tests is the difficulty of interpreting whether a conditioned reinforcer strengthens a response or serves as an eliciting stimulus for subsequent responding. One approach to this problem has been to present the neutral stimulus (CS) on a non-contingent basis to a control group during the training phase of the study. A comparison of this control group with an experimental group where the conditioned stimulus always immediately follows the response during training, reduces the possibility that the CS acts to elicit a response, as well as reducing the design's susceptibility to the generalization decrement argument. This is the rationale for the Backward Conditioning Condition included in the present study.

In summary, the new learning paradigm was selected for use in the present study because of its flexibility in controlling for possible sources of confounding such as generalization decrement and because of its

suitability in assessing the effects of the independent variables without the necessity of introducing primary reinforcement in the test situation.

METHOD

Subjects

Subjects were 200 naive male (100-120 day old) albino rats of the Sprague-Dawley strain. The animals were purchased from the Charles River Breeding Farm, Wilmington, Massachusetts. Animals were individually caged and maintained on an ad lib feeding schedule except as noted in the procedure.

Apparatus

The apparatus for the secondary reinforcement training phase included a (1) runway, (2) approach box, (3) T-maze, and (4) circular maze. Each piece of apparatus was designed to maximize inter-apparatus stimulus differences by using different floors, paint, shapes etc. A complete description of each piece of apparatus appears in Appendix AA.

The neutral stimulus (conditioned stimulus) was random white noise produced by a Grason-Stadler White Noise Generator calibrated to produce a 90 db. sound when connected to a matched set of speakers in the training and test apparatus. Timers controlled the delivery of the white noise during training and testing.

A Lehigh Valley Electronics Co. lever box (Model

No. 18935) ventilated and insulated, was used to test the durability of the secondary reinforcer. The lever box included two bars located on the same wall. When one bar was depressed 3 sec. of the white noise was presented. A response on the other bar produced no consequence. A $7\frac{1}{2}$ w. white light located 3 in. above each bar remained lighted as long as the subject was in the apparatus. Responses on each lever were recorded on a Grason-Stadler Printout Counter at one minute intervals.

Procedure

Two related experiments were conducted.

Experiment I.

The first experiment was designed to demonstrate durable secondary reinforcement by manipulating two independent variables, (1) number of training tasks (one or four) and (2) time at which the conditioned stimulus was presented (simultaneous conditioning procedure or backward conditioning procedure). Forty subjects were randomly assigned to the four training conditions (10 subjects each) which are described below:

1. Condition 1. The subjects received training on four different tasks (runway, approach box, T-maze, and

circular maze). The order of tasks was counter-balanced for each subject in a specific condition. The presentation of primary reinforcement was preceded by the 3 sec. presentation of white noise. This condition will be referred to as the Multiple Task Simultaneous Conditioning Group (MT-SC).

2. Condition 2. The subjects received training on a single task, (either a runway, approach box, T-maze, or circular maze). The order of assigning a task to each subject was predetermined by a schedule which attempted to equalize the number of tasks within each condition. White noise was presented for 3 sec. immediately preceding the delivery of a food pellet to the feeding cup. This condition will further be referred to as the Single Task Simultaneous Conditioning Group (ST-SC).

3. Condition 3. The subjects received training on the four different tasks and the 3 sec. of white noise was presented 30 sec. following the delivery of the food reward. This condition will be designated as Multiple Task Backward Conditioning Group (MT-BC). The backward conditioning groups were included in the present study as a control for possible elicitation effects of the secondary reinforcer during testing. As described

above, the control involved a training procedure in which animals received the conditioned stimulus 30 sec. following a specific response which was reinforced with food. Two levers, one consequted with the conditioned stimulus, the other with no reinforcement, were present in testing. The function of the backward control groups was to demonstrate during testing a separation between response levels for animals trained under the simultaneous (tone contingent) and backward (tone noncontingent) procedures. It was expected that animals trained under the backward conditioning procedure would respond in testing at an operant level. Animals trained under the simultaneous conditioning procedure were expected to show acquisition of the bar press response. In experiments which lack this control procedure, it is impossible to conclude that a genuine secondary reinforcement effect has been demonstrated. It was proposed that if the backward conditioning control group did not produce response rates above an operant level during testing, this control would be eliminated from the design of Experiment II.

4. Condition 4. The subjects received training on a single task. White noise for 3 sec. was presented 30 sec. following the delivery of a food reward. This condition will be designated as Single Task Backward Conditioning

(ST-BC).

Each animal received 120 pairings of food and white noise, 30 pairings on four consecutive days. This number of pairings was based on limited experimentation by Bersh (1951) and Miles (1956) whose work showed that a performance asymptote was not reached prior to 120 pairings of primary and secondary reinforcement in a simple lever pressing task. Hebb (1949) argues for a structural change affecting the strength of an association as a result of overlearning. The 120 trial figure was selected to minimize overlearning effects which, if observed differentially among the four tasks, might have confounded the interpretation of differences obtained between single and multiple task trained subjects.

During training, all animals were maintained on a 23 hr. food deprivation schedule. Once a day all subjects received 13 grms. of Purina Lab Chow following the end of a training session.

White noise was selected as the stimulus to become the conditioned reinforcer, primarily on the basis of its distinctive properties. Its neutrality was demonstrated in a study by Campbell (1955) who showed that 90 db. of white noise produced no facilitation or

suppression of the rat's bar press rates when presented in the absence of primary reinforcement.

During the test phase which began seven days following the end of training, animals from each training condition were tested for one hour in the lever box apparatus previously described. Subjects had the opportunity to press the two bars, one of which had no consequence, the other of which was followed by a 3 sec. presentation of white noise. The tone was randomly assigned to be contingent on either the right or left lever prior to the start of an experimental session. During testing no primary reinforcement was given. All animals spent the time between training and testing in their home cages where they were maintained on an ad lib feeding schedule. Animals were deprived of food 24 hours prior to testing. The design of Experiment I is presented in Table I.

Experiment II.

The second experiment repeated the procedure described in Experiment I but eliminated the two backward conditioning control groups (ST-BC and MT-BC). Experiment II examined durability of secondary rein-

TABLE 1
DESIGN OF EXPERIMENT I

Training Phase				
Groups				
	1	2	3	4
Day 1	Simultaneous Conditioning On Task A*	Simultaneous Conditioning On Task A**	Backward Conditioning On Task A*	Backward Conditioning On Task A**
Day 2	Simultaneous Conditioning On Task A	Simultaneous Conditioning On Task B	Backward Conditioning On Task A	Backward Conditioning On Task B
Day 3	Simultaneous Conditioning On Task A	Simultaneous Conditioning On Task C	Backward Conditioning On Task A	Backward Conditioning On Task C
Day 4	Simultaneous Conditioning On Task A	Simultaneous Conditioning On Task D	Backward Conditioning On Task A	Backward Conditioning On Task D

Testing Phase

All Subjects Tested on Lever Box Task Seven
Days After Completion of Training
Massed Testing 2 Hrs.

Group 1 - Single Task - Simultaneous Conditioning
Group 2 - Multiple Task - Simultaneous Conditioning
Group 3 - Single Task - Backward Conditioning
Group 4 - Multiple Task - Backward Conditioning

Task A - Runway
Task B - Approach Box
Task C - T-maze
Task D - Complex maze

* Single Task Subjects were randomly assigned to one of four different tasks.
** Task order was counterbalanced for Multiple Task Subjects.

forcement as a function of three independent variables: (1) number of training tasks (one or four); (2) amount of delay between the end of training and the time of testing (0-, 1-, 2-, or 4- weeks); and (3) the type of testing (massed or proportionately distributed).

Eighty subjects were trained under each of two "task" conditions (single task or four different tasks). As in Experiment I, one of four training tasks was assigned according to a predetermined order. An equal number of subjects was assigned to each of the training tasks. Training conditions were identical to those for Groups ST-SC and MT-SC in Experiment I.

In the test phase ten animals from each training condition were assigned to a test group according to a predetermined schedule. The schedule was based on a table of random numbers (Jiner, 1962) in which the first 10 out of a possible total of 80 numbers were assigned to test condition 1, the second 10 numbers assigned to test condition 2, continuing until all animals in the single task trained condition had been assigned. This procedure was repeated for the 80 animals trained in the multiple task condition.

All subjects were tested in the lever box. Two variables, (1) type of testing (massed or proportionately

distributed) and (2) length of time since the end of training (0-, 1-, 2-, or 4- weeks) were manipulated. Rats were tested in the following conditions (N=10 per condition):

- (1) Massed Testing: 0-week delay from end of training.
- (2) Massed Testing: 1-week delay from end of training.
- (3) Massed Testing: 2-week delay from end of training.
- (4) Massed Testing: 4-week delay from end of training.
- (5) Distributed Testing: proportionately distributed over the first 3 hours following the end of training.
- (6) Distributed Testing: proportionately distributed over 1-week following the end of training.
- (7) Distributed Testing: proportionately distributed over 2-weeks following the end of training.
- (8) Distributed Testing: proportionately distributed over 4-weeks following the end of training.

Animals were tested for a one hour period in each of the massed testing conditions. The one hour time period was divided into four 15 min. sessions for subjects tested under distributed conditions. For the 0-week delay (No. 5 above) testing occurred on the last day of training with 15 min. intervals separating each of the four test periods. Similarly, 1-week delay (No. 6 above) received four 15 min.

test sessions distributed proportionately over a six day period; 2-week delay (No. 7 above) four 15 min. test sessions distributed proportionately over 13 days; and a 4-week delay (No. 8 above) four 15 min. sessions distributed proportionately over 27 days. The design for Experiment II is shown in Table 2.

Strength of secondary reinforcement, the dependent variable used in both Experiments I and II, was measured on the tone bar. The number of responses on the tone bar and no-tone bar was recorded on the print-out counter at one minute intervals.

RESULTS OF EXPERIMENT I

Table 3 presents the means and standard deviations for responses on the tone and no-tone bars for single and multiple task groups trained under the simultaneous and backward conditioning procedures. The Hartley F max statistic (Winer, 1962) was used to determine if these data met the homogeneity of variance assumption for performing the Analysis of Variance. The results of this test showed that the cell variances were not homogeneous ($F_{\max} = 58.05$; $df=9$; number of variances = 4; $P < .001$).

According to Winer (1962) moderate departures from the assumption of homogeneity do not seriously affect the sampling distribution of the resulting F statistic when certain other conditions are met. This conclusion is supported by Hays (1963) who argues that the assumption can be violated without serious risk provided the number of cases in each sample is equal, a condition satisfied by the design of Experiment I. Studies by Box (1953, 1954) and Boneau (1960) also indicate that the Analysis of Variance statistic is relatively robust with regard to departures from the homogeneity assumption.

For example, Box (1953) demonstrated that in a three factorial design when the variance of factor A equaled the variance of factor B and the variance of factor C was three times that of A and B, the exact sampling distribution (assuming the variance of $A=B=C$) for the F statistic shows the probability equal to .059 of exceeding $F_{.95}$.

The assumption of homogeneity of variance is closely associated with the assumption of a normally distributed population. The departure from normality must be so extreme that it can be readily detected by visual inspection of the data for the departure to have a marked effect on the probability associated with the test of significance (Kirk, 1968). This conclusion is supported in a study by Norton as cited by Lindquist (1953) indicating that the F distribution is relatively unaffected by lack of symmetry of treatment populations. Visual inspection of the population variance obtained in each of the treatment groups for Experiment I shows no marked departures from this assumption within the critical groups.

The most compelling argument that can be made for proceeding with the Analysis of Variance is based on the amount of error variance expected with the simultaneous and backward conditioning factor. Since backward condi-

tioning by design should have had no effect on the animals' rate of responding, meaning that they should not press the lever, then it would follow that the variances for the bar press response generated by Es trained under the backward conditioning procedure would theoretically be very low. In fact, the data (Table 3) show that the lowest variances occurred for groups trained under the backward conditioning procedure with no overlap with the variances generated by animals trained under the simultaneous conditioning procedure. The same argument can be made for the variances associated with the tone and no-tone bars since the no-tone bar should theoretically have had no effect on the animals' response behavior. Winer (1962) suggests that tests for homogeneity of variance are appropriate principally when the experimenter has no knowledge about the effect of treatments upon the variance.

In summary, the author is convinced of the appropriateness of proceeding with the Analysis of Variance as the statistic for analyzing the data from Experiment I. However, as an additional precaution against any possible bias contributed by the lack of homogeneity, all alpha levels were set

TABLE 3

MEANS AND STANDARD DEVIATIONS FOR TOTAL RESPONSES IN 60 MINUTES ON THE TONE AND NO-TONE BARS FOR MULTIPLE AND SINGLE TASK GROUPS TRAINED UNDER SIMULTANEOUS AND BACKWARD CONDITIONING PROCEDURES.

Simultaneous Conditioning						
	Multiple Task			Single Task		
	<u>$\bar{X}$</u>	<u>SD</u>	<u>N</u>	<u>$\bar{X}$</u>	<u>SD</u>	<u>N</u>
Tone	20.90	3.62	10	19.70	6.40	10
No-Tone	7.10	3.30	10	3.80	2.95	10
Backward Conditioning						
Tone	4.30	0.84	10	3.30	1.33	10
No-Tone	5.50	0.77	10	3.10	1.23	10

at the .001 level in both Experiment I and Experiment II.

A three-way Analysis of Variance with repeated measures on the tone no-tone variable was performed on the data. The results of this analysis are presented in Table 4. The primary purpose of Experiment I was to demonstrate the superiority of the simultaneous conditioning procedure in contrast to the backward conditioning procedure. The data support this contention ($F=8.59$; $df=1/16$; $P<.001$). The mean number of bar press responses for the simultaneous and backward conditioning procedures were 20.30 and 3.80 responses respectively.

The hypothesis that animals trained on a series of tasks would emit more responses on the tone bar during testing than animals trained on a single task was not supported ($F<1.00$). The mean number of bar press responses emitted by ss trained on four different tasks was 12.60, in contrast to a mean of 11.50 bar press responses for ss trained on a single task.

To determine if a true secondary reinforcement effect had been obtained, responses on the tone and no-tone bars were analyzed. If the tone acted as a true secondary reinforcer, it was predicted that ss

TABLE 4

THREE WAY ANALYSIS OF VARIANCE REPEATED MEASURES
ON THE TONE-NO TONE VARIABLE BASED ON TOTAL RE-
SPONSES ON THE TONE AND NO TONE BARS DURING THE
60 MINUTE TEST PERIOD

Source	SS	df	ms	F	P
Total	7585.35	79			
Between subjects	5177.94	19			
Type of Conditioning	1795.51	1	1795.51	8.59	< .001
Single or Multiple Task	35.12	1	35.12	0.17	NS
Task X Conditioning	2.81	1	2.81	0.01	NS
Error b	3344.50	16	209.03		
Within subjects	2407.45	60			
Tone/No tone	6851.52	1	851.52	84.64	< .001
Tone X Conditioning	987.01	1	987.01	98.11	< .001
Tone X Tasks	1.00	1	1.00	0.10	NS
Tone X Tasks X Conditioning	4.52	1	4.52	0.45	NS
Error w	563.40	56	10.06		

would make a greater number of responses on the tone contingent bar. This finding was supported ($F=84.64$; $df=1/56$; $P .001$). Significantly more responses were made on the tone bar ($\bar{X} = 12.05$) than on the no-tone bar ($\bar{X} = 4.85$).

A significant interaction was obtained between performance on the tone and no-tone bars and type of conditioning ($F=98.11$; $df=1/56$; $P .001$). Animals trained by simultaneous conditioning made more responses on the tone bar ($\bar{X} = 20.30$) than the no-tone bar ($\bar{X} = 5.45$) as compared to animals trained by the backward conditioning procedure ($\bar{X} = 3.80$ responses on the tone bar; $\bar{X} = 4.30$ responses on the no-tone bar).

Data were further analyzed according to the mean number of responses emitted during successive 15 minute test blocks. Response data on the tone bar in blocks of 15 minutes are plotted in Figure 1. This figure shows that the highest rate of responding occurred during the first 15 minute test block and that by the third 15 minute block, the responding of virtually all animals had extinguished. This result is so apparent that no statistical procedures were performed.

FIG. 1. MEAN NUMBER OF RESPONSES ON THE TONE BAR OVER 60 MIN. TEST SESSION.

The results of Experiment I clearly indicate that the use of the simultaneous conditioning technique is a sufficient condition for the establishment of a secondary reinforcer. In addition, backward conditioning was shown to be an ineffective procedure for the establishment of a conditioned reinforcer. Thus the backward conditioning control was excluded from Experiment II.

Although the experimental results strongly suggest the conclusion that training on multiple versus single tasks does not differentially affect the strength of secondary reinforcement, it was decided to retain the single task variable in Experiment II in order to test the reliability of the results obtained in Experiment I.

RESULTS OF EXPERIMENT II

Table 5 presents the means and standard deviations for the total number of responses on the tone bar for each of the 16 groups in the experiment.

Since the observed F max statistic did not exceed the critical value, the hypothesis of homogeneity of variance was considered tenable (Winer, 1962) ($F=3.21$; $df=9$; Number of variances =16; $P>.05$).

Table 6 summarizes the three-way Analysis of Variance for total number of responses on the tone bar for the 60 min. test period. For subjects in the distributed test condition the total number of responses during the four 15 min. test periods was used.

Subjects trained on a single task pressed the tone bar a mean of 47.71 times in 60 min. as compared to a mean of 47.63 times for subjects trained on multiple tasks. This difference was not significant and agreed with the results concerning the task variable reported in Experiment I ($F 1.00$).

A significant difference was observed between the massed and distributed test trial conditions, thus confirming the hypothesis that rats tested under

TABLE 5

MEANS AND STANDARD DEVIATIONS FOR RESPONSES ON THE TONE BAR FOR SINGLE AND MULTIPLE TASK GROUPS TESTED AT 0-, 1-, 2-, or 4- WEEKS DELAY, UNDER MASSED OR PROPORTIONATELY DISTRIBUTED TEST PROCEDURES.

Single Task Trained Subjects				
Delay Condition	Massed Trials		Distributed Trials	
	X	SD	X	SD
0-week	65.2	5.6	83.2	4.8
1-week	29.1	4.2	73.4	6.8
2-week	17.8	4.6	50.0	5.4
4-week	16.7	4.5	46.3	4.4
Multiple Task Trained Subjects				
0-week	67.0	6.2	84.6	4.1
1-week	27.7	3.8	75.0	6.0
2-week	16.9	4.6	47.5	4.4
4-week	16.2	4.5	46.1	5.3

TABLE 6

THREE-WAY FIXED EFFECTS ANALYSIS OF VARIANCE FOR EXPERIMENT II BASED ON TOTAL NUMBER OF BAR PRESS RESPONSES FOR THE 60 MINUTE TESTING PERIOD

Source of Variation	SS	df	ms	F	P
TOTAL	98057.50	159.00			
Training Tasks Single/Multiple	0.25	1.00	0.25	0.007	NS
Delay of Testing 0-, 1-, 2-, 4-Weeks	49640.38	3.00	16546.79	435.064	< .001
Type of Testing Massed/Distributed	38906.25	1.00	38906.25	1022.960	< .001
Training Task X Delay of Testing Interaction	55.63	3.00	18.54	0.488	NS
Training Task X Type of Testing Interaction	1.31	1.00	1.31	0.035	NS
Delay of Testing X Type of Testing Interaction	3948.81	3.00	1316.27	34.609	< .001
Training Task X Type of Testing X Delay of Testing Interaction	28.13	3.00	9.38	0.247	NS
Error	5476.75	144.00	38.03		

distributed conditions would emit a greater number of responses than rats tested under massed conditions ($F=1022.96$; $df=1/144$; $P .001$). Subjects tested under proportionately distributed trials pressed the tone bar approximately twice as frequently as subjects tested under massed trials; the mean number of bar presses being 63.26 and 32.08 for the two groups respectively.

A third variable, delay of test (0-, 1-, 2-, or 4- weeks) produced significant differences among the four time delay periods ($F=435.06$; $df=3/144$; $P .001$). The mean number of bar press responses were 37.50, 25.65, 16.52, and 15.66 for the 0-, 1-, 2-, and 4-week delay conditions respectively. In order to determine which of the delay conditions varied significantly from each other, the Scheffé Post Test Analysis for comparing differences among means (Winer, 1962) was performed. The results of this analysis are presented in Table 7. The analysis shows that the means of all conditions varied significantly from each other with the exception of the 2- and 4- week delay condition. The data support the hypothesis that strength of secondary reinforcement decreases over time from original training as a function of the increasing

TABLE 7

SCHIFFE'S S-METHOD FOR MEAN COMPARISON APPLIED TO
DELAY OF TESTING (FACTOR B)

B	Mean	Differences between Means			
		B4	B3	B2	B1
4	15.6625	--	.8625	9.9875	21.8375
3	16.5250		--	9.1250	20.9750
2	25.6500			--	11.8500
1	37.5000				--

Underlined comparisons ($P < .001$)

$$\begin{aligned}
 S &= \sqrt{(4-1) \quad (5.79) \quad (38.03)} \quad (1\sqrt{((10) \quad (2) \quad (2))}) \\
 &= (4.1677) \quad (.9751) \\
 &= 4.0640
 \end{aligned}$$

B1 0-week delay
B2 1-week delay
B3 2-week delay
B4 4-week delay

retention interval.

A significant interaction was found between type of testing (massed vs. distributed) and delay of testing (0-, 1-, 2-, and 4- weeks) ($F=34.61$; $df=3/144$; $P<.001$). In order to determine at what points the interaction was significant, a Scheffé Test (Winer, 1962) was performed on the data. The results of this analysis are presented in Table 8. The analysis shows that all data points differ significantly from each other with the exception of two comparisons, 1) the distributed test 2- and 4-week delay condition, and 2) the massed test 2- and 4-week delay condition. These data support the earlier findings that no significant response decrement occurs between the 2- and 4- week delay conditions while showing that Ss tested under distributed conditions maintain a significantly higher response rate after two or four weeks than Ss tested under massed conditions. These data are visually depicted in Figure 2. The results of this analysis support the observation that the interaction is determined primarily by massed and distributed testing at the 0- and 1- week delay intervals.

The combination of the three independent variables failed to produce a significant third order interaction,

TABLE 8

SCHÉFFÉ'S S-METHOD FOR MEAN COMPARISONS APPLIED TO
 DELAY OF TESTING (FACTOR B) X TYPE OF TESTING (FAC-
 TOR C) INTERACTION

			<u>Differences between Means</u>							
B	C	Mean	<u>4,1</u>	<u>3,1</u>	<u>2,1</u>	<u>4,2</u>	<u>3,2</u>	<u>1,1</u>	<u>2,2</u>	<u>1,2</u>
4	1	16.45	---	.90	<u>11.95</u>	<u>29.75</u>	<u>32.30</u>	<u>49.65</u>	<u>57.75</u>	<u>67.45</u>
3	1	17.35		---	<u>11.05</u>	<u>28.85</u>	<u>31.40</u>	<u>48.75</u>	<u>56.85</u>	<u>66.55</u>
2	1	28.40			---	<u>17.80</u>	<u>20.35</u>	<u>37.70</u>	<u>45.80</u>	<u>55.50</u>
4	2	46.20				---	<u>2.55</u>	<u>19.90</u>	<u>28.00</u>	<u>37.70</u>
3	2	48.75					---	<u>17.35</u>	<u>25.45</u>	<u>35.15</u>
1	1	66.10						---	<u>8.10</u>	<u>17.80</u>
2	2	74.20							---	<u>9.70</u>
1	2	83.90								---

Underlined comparisons ($P < .001$)

$$\begin{aligned}
 S &= \sqrt{(4-1)(2-1)(5.79)} \sqrt{(38.03)(1/((10)(2)))} \\
 &= (4.1677)(1.3789) \\
 &= 5.7469
 \end{aligned}$$

B1 0-week delay
 B2 1-week delay
 B3 2-week delay
 B4 4-week delay

C1 Massed test trials
 C2 Distributed test trials

FIG. 2. EXPERIMENT II: INTERACTION BETWEEN TYPE OF TESTING AND DELAY OF TESTING

thus disconfirming the hypothesis that secondary reinforcement strength would be greatest under multiple task training, and distributed acquisition trials when tested immediately following training ($F 1.00$).

To determine whether proportionately distributed testing results in significant decrements in number of responses for successive test periods, a three-way Analysis of Variance was performed with repeated measures on the distributed test factor. Table 9 presents the mean number of responses on the tone bar for the eight groups tested. The means represent the responses made during the 15 min. test periods. Referring to Table 10 which shows the results of the analysis, it can be seen that Ss trained on a single task made almost exactly the same number of responses on the tone bar as Ss trained on multiple tasks; the means being 15.81 and 15.85 responses respectively ($F < 1.00$).

The test delay factor (0-, 1-, 2-, or 4- weeks) again was significant ($F=145.00$; $df=3/72$; $P < .001$), thus supporting the results of the previous analysis.

The critical factor, four 15 minute trials was also significant ($F=1726.54$; $df=3/216$; $P < .001$). The response means for the four successive 15 minute periods

TABLE 9

MEANS AND STANDARD DEVIATIONS FOR TOTAL RESPONSES ON THE TONE BAR FOR SINGLE AND MULTIPLE TASK SUBJECTS TESTED 0-, 1-, 2-, OR 4-WEEKS DELAY, UNDER PROPORTIONATELY DISTRIBUTED TEST TRIALS.

Proportionate Test Trials	Single Task Trained Subjects					
	0-Week Delay		1-Week Delay		2-Week Delay	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
1	22.6	2.3	21.7	1.7	21.1	2.7
2	24.1	1.6	22.4	2.1	12.6	2.5
3	20.4	3.2	16.2	1.4	9.8	2.9
4.	16.1	2.6	13.1	2.8	6.5	3.4
					4.7	2.5
	Multiple Task Trained Subjects					
	0-Week Delay		1-Week Delay		2-Week Delay	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
1	24.0	1.8	21.5	2.5	18.8	2.0
2	24.5	1.2	21.3	1.4	13.2	2.6
3	19.3	3.5	17.4	1.7	9.5	1.3
4	16.8	2.6	14.8	1.5	6.2	3.4
					6.1	1.6
					18.9	3.5

TABLE 10

THREE FACTOR ANALYSIS OF VARIANCE WITH REPEATED MEASURES ON THE TEST TRIALS FACTOR
(SUCCESSIVE 15 MINUTE TEST PERIODS)

Source of Variation	SS	df	ms	F	P
TOTAL	16918.75	319.00			
BETWEEN SUBJECTS	6204.50	79.00			
Training Task(s) Single/Multiple	0.94	1.00	0.94	0.08	NS
Delay of Testing 0-, 1-, 2-, 4-Weeks	5308.81	3.00	1769.60	145.00	<.001
Training Task X Delay of Testing Interaction	16.06	3.00	5.35	0.44	NS
Error Term	878.69	72.00	12.20		
WITHIN SUBJECTS	10714.25	240.00			
Trial Session (T, T, T, T) 1 2 3 4	5179.63	3.00	1726.54	79.40	<.001
Training Task X Trial Session Interaction	21.63	3.00	7.21	0.33	NS
Delay of Testing X Trial Session Interaction	759.25	9.00	84.36	3.88	<.001
Training Task X Delay of Testing X Trial Session Interaction	56.69	9.00	6.30	0.29	NS
Error Term	4697.06	216.00	21.75		

were 21.09, 18.03, 13.78, and 10.56 responses respectively. The results of the Scheffé Post Test Analysis (Winer, 1962) shows that the means for the four trial periods varied significantly from each other and that the response rate decreased significantly over successive trials. The results of this analysis are presented in Table 11.

The Analysis of Variance (Table 10) further shows a significant interaction between the trial factor and test interval or delay factor ($F=84.36$; $df=9/216$; $P<.001$). In order to determine the function of this interaction the Scheffé Post Test Analysis (Winer, 1962) was performed on the data. The results of this analysis are shown in Table 12. Figure 3 visually depicts the shape of the interaction. Based on the results of the Scheffé Post Test Analysis, response rates for the first 15 minute test session did not vary significantly for the 0-, 1-, 2-, or 4- week delay condition, thus confirming the contention that all SS responded at the same rate during the initial 15 minute test trial period. At the remaining trial sessions (T_2 , T_3 , and T_4) the 0- and 1- week delay groups did not vary significantly at T_2 , T_3 , and T_4 . The response rates for the 0- and 1- week delay condi-

TABLE 11

SCHEFFE'S S-METHOD FOR MEAN COMPARISONS APPLIED TO
TRIAL SESSION (FACTOR 2) MEANS

C	Mean	Differences between Means			
		C4	C3	C2	C1
4	10.5375	-----	<u>3.2375</u>	<u>7.5000</u>	<u>10.5500</u>
3	13.7750		-----	<u>4.2625</u>	<u>7.3125</u>
2	18.0375			-----	<u>3.0500</u>
1	21.0875				-----

Underlined comparison ($P < .001$)

$$\begin{aligned}
 S &= \sqrt{(4-1) (5.79)} \sqrt{(21.75) (1/(10)) (2) (4)} \\
 &= (4.1677) (.5214) \\
 &= 2.1731
 \end{aligned}$$

C1 First 15 minute trial session
 C2 Second 15 minute trial session
 C3 Third 15 minute trial session
 C4 Fourth 15 minute trial session

TABLE 12

SCHIFFER'S S-METHOD FOR MEAN COMPARISONS APPLIED TO DELAY OF TESTING (FACTOR B) TEST TRIAL INTERACTION

B	C	Mean	Differences between means															
			4,4	3,4	4,3	3,3	3,2	4,2	2,4	1,4	2,3	4,1	3,1	1,3	2,1	2,2	1,1	1,2
4	4	5.40	-----	0.95	2.90	4.25	7.50	7.70	8.55	11.05	11.40	14.10	14.55	14.95	16.20	16.45	17.90	18.90
3	4	6.35	-----	1.95	3.30	6.55	6.75	7.60	10.10	10.45	13.15	13.60	14.00	15.25	15.50	16.95	17.95	
4	3	8.30	-----	1.35	4.60	4.80	5.65	8.15	8.50	11.20	11.65	12.05	13.30	13.55	15.00	16.00		
3	3	9.65	-----	3.25	3.45	4.30	6.80	7.15	9.85	10.30	10.70	11.95	12.20	13.65	14.65			
3	2	12.90	-----	0.20	1.05	3.55	3.90	6.60	7.05	7.45	8.70	8.95	10.40	11.40				
4	2	13.10	-----	0.85	3.35	3.70	6.40	6.85	7.25	8.50	8.75	10.20	11.20					
2	4	13.95	-----	2.50	2.85	5.55	6.00	6.40	7.65	7.75	9.35	10.35						
1	4	16.45	-----	0.35	3.05	3.50	3.90	5.15	5.40	6.85	7.85							
2	3	16.80	-----	2.70	3.15	3.55	4.80	5.05	6.50	7.50								
4	1	19.50	-----	0.45	0.85	2.10	2.35	3.80	4.80									
3	1	19.95	-----	0.40	1.65	1.90	3.35	4.35										
1	3	20.35	-----	1.25	1.50	2.95	3.95											
2	1	21.60	-----	0.25	1.70	2.70												
2	2	21.85	-----	1.45	2.45													
1	1	23.30	-----	1.00														
1	2	24.30	-----															

Underlined comparisons (P<.001: S= 5.8760

FIG. 3. EXPERIMENT II. INTERACTION BETWEEN TEST DELAY (0-, 1-, 2-, 4- WEEKS) AND SUCCESSIVE 15 MIN. TEST PERIODS (T_1, T_2, T_3, T_4).

tions did vary significantly from the response rates for the 2- and 4- week delay conditions at T_2 , T_3 , and T_4 .

It should be pointed out that the amount of time which elapsed since the end of training is proportionate and not absolute for each data point on the abscissa of Figure 3. In other words, at T_1 , the absolute time since the end of training was 1 hour for the 0-week, 42 hours for the 1-week, 84 hours for the 2-week, and 168 hours for the 4-week delay period. It is the proportionate time distribution across the 0-, 1-, 2-, or 4- week period which is treated as the fixed factor in the Analysis of Variance and post treatment tests. The interaction appears to occur as a result of the differential rate of response decrement for the 0- and 1- week condition vs. 2- and 4- week conditions, with the 2- and 4- week delay ss showing a greater decrement.

Responses on the no-tone bar for each of the 16 groups tested in Experiment II ranged between 0 and 6 bar presses, with a mean of 1.56 responses for the 60 min. test session. These data support the contention that rats would respond more on the bar which was reinforced with white noise. The separation in response rates for the tone and no-tone bars clearly indicates

that a true secondary reinforcement effect has been established in Experiment II.

DISCUSSION

The results from both Experiment I and II indicate that the simultaneous conditioning procedure was effective in establishing white noise as a conditioned reinforcer. Backward conditioning as used in Experiment I was not sufficient for the establishment of a secondary reinforcer as tested in a new learning situation. These data are in agreement with findings reported by Egger and Miller (1962) who used a similar pseudo-conditioning control. The significant differences in response rates on the tone bar for simultaneous and backward conditioning procedures, in addition to the clear separation in response rates on the tone and no-tone bars, indicated that a valid secondary reinforcement effect was produced and that white noise in the present experiment did not act to elicit bar press responding.

The present findings indicate that when pairings of primary and secondary reinforcement as opposed to amount of learning, is the equated factor in establishing a secondary reinforcer, the strength of the secondary reinforcer is neither facilitated nor inhibited by training on a single or four different training tasks. The data from Experiment I and II fail to

support the prediction that rats which receive secondary reinforcement training on four different tasks would emit more bar press responses during testing than animals trained on a single task. The results indicate that the number of training tasks was not an effective variable in the present experiments. The author suspects that the number of pairings of conditioned stimulus and primary reinforcement and not the number of different training tasks was the important variable in establishing a neutral stimulus as a secondary reinforcer.

The initial hypothesis suggesting the effectiveness of multiple training tasks in establishing secondary reinforcement was based on the principle that greater response generalization should occur if animals received white noise paired with food in a number of different response conditions (running a circular maze to approach food, running a T-maze to approach food, running a straight alley to approach food, and making a food cup orienting response to approach food) than if it was paired with a single task. An alternative explanation as to why stronger secondary reinforcement effects were not observed for multiple-task trained subjects is that each of the

four tasks involved the same food cup orienting and consummatory response. Regardless of what different responses the rat made in the chain (white noise - food orienting response - food - consummatory response), the final response in the chain was the same for all animals. The similarity of the food orienting and consummatory responses was increased by the use of the same bronze food cup in three of the tasks and the location of the food cup in all four tasks. In future research, an alternative test of the hypothesis might involve the use of distinctly different food orienting responses such as rearing on hind legs to obtain food versus head poking to obtain food. The results of the present experiment suggest that the general stimulus and response characteristics of the training task do not appear as important as the response which the animal makes between presentation of the conditioned stimulus and primary reinforcement.

The proportionate distribution of test trials was the most critical factor in demonstrating a strong secondary reinforcement effect. In accordance with the initial prediction, rats tested under proportionately distributed test conditions made more re-

sponses than rats tested under massed trials. Rats tested for one hour at the end of 0-, 1-, 2-, or 4-weeks made only half as many total responses as animals tested under four 15 min. test trials proportionately distributed over the 0-, 1-, 2-, or 4-week period. When data are analyzed for the first 15 min. test trial (T_1 at 0- and 1-week following the end of training) the results are consistent with previous studies which show that once established, classically conditioned associations show little weakening until exposed to extinction procedures (Liddell, et. al., 1934; Marquis and Hilgard, 1936; and Skinner, 1953). However, when testing is extended (T_2 , T_3 , and T_4 , 0-, 1-, 2-, and 4-weeks following the end of training) it can be seen that delay of testing of secondary reinforcement is an effective variable in assessing secondary reinforcement strength.

It is interesting to note that animals tested in Experiment I under massed conditions, emitted approximately 85 percent of their total bar press responses during the first 15 minutes of testing, and by the third 15 minute period, the responding had declined to a near zero level (Figure 1). It

should be pointed out that the bar press rate is an indirect measure of the strength of a classically conditioned association in that it involves both the acquisition and extinction of an operant response.

As predicted, all animals tested in Experiment II emitted the most bar press responses at the 0-week delay condition ($\bar{X}$ = 37.50) followed by significant decrements at the 1- (25.65) and 2- (16.52) week conditions. The fact that the 2- (16.52) and 4- (15.66) week delay conditions did not vary significantly indicates that some asymptotic level of responding may have been reached. On the basis of these data, one would predict that the test delay period (time from the end of training) could be extended indefinitely without observing a return of the animal's response rate to baseline levels (0 to 5 bar press responses per 60 min. test situation). This prediction is based on a combination of decay and interference theories of forgetting.

Decay theory (Hebb, 1949) assumes that some loss of the association strength between white noise and food will occur as a function of the amount of time which has passed since the end of

training. This prediction is supported by the data of subjects tested under massed conditions (0-, 1-, and 2- weeks following the end of training) (Figure 2), and by subjects tested at T_1 under proportionately distributed conditions, 2- and 4- weeks following the end of training (Figure 3). Interference theory (Underwood, 1949) predicts that the strength of the association between white noise and food will remain strong as long as the conditioned stimulus (white noise) is not presented with a stimulus other than food during the interim between training and testing. The data from subjects tested at T_1 under distributed procedures, 0- and 1- week following the end of training, indicate that little fading in the strength of the original association has occurred when animals are tested 1 hour (0- week delay) and 42 hours (1-week delay) following the end of training (Figure 3). It appears that the reduction in strength of secondary reinforcement may occur as a function of both the decay of the original association between food and white noise (33), and the interference which results when the white noise is presented without the consequence of primary reinforcement. It would

be interesting in terms of future research to extend the delay period beyond the four week limit tested in Experiment II, in order to determine the shape of the acquisition-extinction curve for massed and distributed test subjects.

The data indicate that for subjects tested under proportionately distributed conditions, the rate of responding for the 0- and 1- week delay conditions did not differ significantly. Similarly the rates of responding for the 2- and 4- week delay conditions did not differ significantly. However, the rates of responding for the 0- and 1- week delay were significantly different from the 2- and 4- week delay conditions for the second, third, and fourth 15 minute test trial period. These data showing significant differences in secondary reinforcement determined by whether testing is massed or distributed, emphasize the importance of the testing procedure in drawing conclusions about the strength of secondary reinforcement.

The sustained high level of responding over distributed test trials (0- and 1- week delay conditions) may be partially due to the occurrence of spontaneous recovery. The rest between massed 15

minute extinction trials allows for spontaneous recovery of the bar press response. In Experiment II, the first occasion for spontaneous recovery to contribute to the data (T_2), responding was back to its original level (T_1). This 100 percent recovery is in accordance with results reported by Pavlov (1927) but in exception to the studies which show that more often, spontaneous recovery restores something like 50 percent of the response strength lost in extinction (Kimble, 1961). Because the rats tested under proportionately distributed trials were responding at high levels at the end of the first 15 minute test session, it is possible that only a small amount of extinction had occurred.

A question of interest in the present investigation was whether the secondary reinforcement was still effective at the end of four weeks of distributed testing. To begin to answer this question, it is possible to compare response levels for the final 15 minute test period of the 2- and 4- week distributed test group with pilot data collected by the author.

These preliminary data indicated that rats

(N=10) which received secondary reinforcement training on a single task and which were tested in a lever box one week following the end of training, pressed the bar an average of 3.7 times in a 60 minute period when the bar press response produced no consequence. A second group of pilot animals (N=8) which received single task training but which received the secondary reinforcement 30 seconds after making a food orienting response, pressed the tone contingent lever an average of 4.5 responses for the 60 min. test period. A third group of animals (N=6) was placed in a lever box which had both tone contingent and tone non-contingent bars present. The mean total responses on the tone contingent bar for this group which did not receive any secondary reinforcement training was 4.8 for a 60 minute test period.

Rats tested at T_4 , 2- and 4- weeks following the end of training performed only slightly above this operant level, producing an average of five responses for the final 15 minute period of distributed testing. Although the pilot data cannot be used as a direct comparison or baseline, it seems probable that animals tested under distributed trials

had reached "operant level" by the fourth week following the end of training.

In conclusion, the results of the present investigation indicate that 1) a durable secondary reinforcement effect can be established using a simultaneous conditioning procedure during training. 2) The results further indicate that the number of pairings of the conditioned stimulus with primary reinforcement is a more critical variable in establishing a conditioned stimulus as a durable secondary reinforcer than is the amount of experience an animal has with a number of different tasks during training. 3) Distributed testing as an index of the strength of secondary reinforcement produces higher rates of responding than massed testing. 4) Response rates decrease significantly as retention intervals (the period between the end of training and the start of testing) increase. The critical point at which the secondary reinforcer loses its original reinforcing strength occurs in the present study between the seventh and fourteenth day of testing. 5) The most important finding in the study is that differential secondary reinforcement effects occur as a function of the interaction between type of

testing and delay of testing. As can be seen from Experiment II, the type of test, massed or distributed, is an important variable in assessing the strength of secondary reinforcement. In designing future studies, the massed and distributed testing procedure should be carefully evaluated in terms of its potential interaction with the retention intervals required of a subject.

Finally, the results of the present experiment indicate that durable secondary reinforcement can be reliably demonstrated without presenting primary reinforcement in the test situation. This result should in no way divert attention from the study of secondary reinforcement using a chained or concurrent operant paradigm. In recent years the new learning procedure has not been the preferred paradigm of most researchers because of the small magnitude of secondary reinforcement effects obtained when it is used. The sizable secondary reinforcement effects observed in the present study should renew interest in the learning paradigm as an effective procedure for assessing the strength of secondary reinforcement.

APPENDIX AA

APPARATUS DESCRIPTION

T-maze

Dimensions: arms - 6" long, 12" high; stem - 6" wide, 15" long, 12" high. The maze was painted flat black. A bronze food cup was located at the left arm of the maze, $1\frac{1}{4}$ in. above the metal grid floor. A photoelectric cell was positioned on opposite walls of the left arm, 4 in. from the food cup. (In order to reduce the amount of light and the possible confounding effects of an additional conditioned stimulus, the light source was covered with black electricians' tape, thus reducing the aperture to less than one millimeter in diameter. This control was made in each of the subsequent pieces of apparatus).

Circular maze

Dimensions: 5' in circumference, 10" high, 6" wide. The maze was painted silver. The photoelectric cell was positioned $\frac{1}{2}$ in. in front of the food cup. The food cup was located $\frac{1}{4}$ in. above the wire mesh floor. Blocks of wood were placed on the wire floor at unequal intervals over the $3\frac{1}{2}$ ' run from the start position to the food cup.

Alley

Dimensions: 6" wide, 36" long, 8" high. The alley was painted a flat silver. It had grid floors and a bronze food cup. The photoelectric cell was positioned 3 in. front of the food cup.

Approach Box

Dimensions: 6" wide, 6" long, 12" high. The box was painted flat black except for a front panel which was painted with black and white stripes. The bronze food cup was located on the striped panel, $\frac{1}{4}$ in. above the grid floor. The photoelectric cell was positioned $\frac{1}{2}$ in. in front of the food cup.

Lever Box

A standard Lehigh Valley Electric Company Lever Box (Model No. 18935) was used in the test situation. Two bars were present throughout testing.

REFERENCES

- Armus, H. L., and Garlich, M. M. Secondary reinforcing strength and schedules of primary reinforcement. Journal of Comparative and Physiological Psychology, 1961, 54, 55-58.
- Boneau, C. A. The effects of violation of assumptions underlying the f test. Psychological Bulletin, 1960, 57 (1), 49-64.
- Boyle, R. E. Secondary reinforcement and a test of two reinforcement hypotheses concerning the PR effect. Journal of Comparative and Physiological Psychology, 1961, 54, 565-571.
- Box, G. E. P. Non-normality and tests on variances. Biometrika, 1953, 160, 268-282.
- Box, G. E. P. Some theorems on quadratic forms applied in the study of analysis of variance problems, II. Effects of inequality of variance and of conclusion between errors in the two-way classification. Annals of Mathematical Statistics, 1954, 25, 484-498.
- Campbell, B. A. The fractional reduction in noxious stimulation required to produce "just noticeable" learning. Journal of Comparative and Physiological Psychology, 1955, 48, 141-148.
- D'Amato, M. R., Lachman, R., and Kivy, P. Secondary reinforcement as affected by reward schedule and the testing situation. Journal of Comparative and Physiological Psychology, 1958, 51, 737-751.
- Egger, M. D., and Miller, N. E. Secondary reinforcement in rats as a function of information value and reliability of the stimulus. Journal of Experimental Psychology, 1962, 64, 97-104.
- Ferster, J. B., and DeMyer, M. K. A method for the experimental analysis of the behavior of autistic children. American Journal of Orthopsychiatry, 1962, 32, 89-98.
- Ferster, C. B., and Skinner, B. F. Schedules of reinforcement. 1957, New York: Appleton-Century-Crofts.

Hays, W. L. Statistics for Psychologists, 1963, New York: Holt, Rinehart and Winston Inc.

Hebb, D. O. The organization of behavior. 1949, New York: Wiley.

Hendry, D. P. Conditioned reinforcement. 1969, Homewood, Ill.: Dorsey Press.

Herrnstein, R. J. Secondary reinforcement and rate of primary reinforcement. Journal of the Experimental Analysis of Behavior, 1961, 4, 267-272.

Kanfer, F. H. Incentive value of generalized reinforcers. Psychological Reports, 1960, 7, 531-538.

Kanfer, F. H., and Matarazzo, J. D. Secondary and generalized reinforcement in human learning. Journal of Experimental Psychology, 1959, 58, 400-404.

Kelleher, R. T., and Fry, W. T. Stimulus functions in chained fixed intervals schedules. Journal of the Experimental Analysis of Behavior, 1962, 5, 167-173.

Kelleher, R. T., and Gollub, L. R. A review of positive conditioned reinforcement. Journal of the Experimental Analysis of Behavior, 1962, 5, 543-597.

Kelleher, R. T., and Schoenfeld, W. K. Principle of Psychology. 1950, New York: Appleton-Century-Crofts.

Kimble, G. A. Hilgard and Marquis' conditioning and learning. 1961, New York: Appleton-Century-Crofts.

Kirk, R. E. Experimental Design procedures for the Behavioral Sciences. 1968, Belmont California: Brooks/Cole Publishing Company.

Klein, R. M. Intermittent primary reinforcement as a parameter of secondary reinforcement. Journal of Experimental Psychology, 1959, 58, 423-427.

Liddell, H. S., James, W. T., and Anderson, O. D. The comparative physiology of the conditioned motor reflex: based on experiments with the pig, dog, sheep, goat, and rabbit. Comparative Physiology Monographs, 1934, 11, No. 5.

Lindquist, E. P. Design and Analysis of Experiments in Psychology and Education. 1953, Boston: Houghton Mifflin Company.

Marquis, D. G., and Hilgard, E. R. Conditioned lid responses to light in dogs after removal of the visual cortex. Journal of Comparative Psychology, 1936, 22, 157-178.

Marx, M. H., and Knarr, F. A. Long-term development of reinforcing properties of a stimulus as a function of temporal relationships to food reinforcement. Journal of Comparative and Physiological Psychology, 1963, 56, 546-550.

McClelland, D. C. Personality. 1951, New York: Dryden Press.

McNamara, H. J., and Page, A. B. An elaboration of Zimmerman's procedure for demonstrating durable secondary reinforcement. Psychological Reports, 1962, 11, 802-803.

Miles, R. C. The relative effectiveness of secondary reinforcers throughout deprivation and habit-strength parameters. Journal of Comparative and Physiological Psychology, 1956, 49, 126-130.

Miller, N. E. Learnable drives and rewards. In S. S. Stevens (Ed.), Handbook of Experimental Psychology. 1951, New York: McGraw-Hill.

Myers, J. L. Secondary reinforcement: A review of recent experimentation. Psychological Bulletin, 1958, 55, 284-301.

Myers, N. A. Extinction following partial and continuous primary reinforcement. Journal of Experimental Psychology, 1960, 60, 172-179.

Pavlov, I. P. Conditioned Reflexes. (Translated by G. V. Anrep) 1927, London, Oxford University Press.

Reynolds, W. F., Freedman, P. E., and Richter, M. L. Secondary reinforcement effects in a T-maze following direct placement training. Psychological Reports, 1961, 8, 345-349.

Saltzman, I. J. Maze learning in the absence of primary reinforcement: A study of secondary reinforcement. Journal of Comparative and Physiological Psychology, 1949, 42, 161-173.

Skinner, B. F. Science and human Behavior. 1953, New York: Macmillan.

Underwood, B. J. Experimental Psychology. 1949, New York: Appleton-Century-Crofts, Inc.

Wike, E. L. Secondary Reinforcement. 1966, New York: Harper and Row.

Wike, E. L., and Barrientos, G. Secondary reinforcement and multiple drive reduction. Journal of Comparative and Physiological Psychology, 1958, 51, 640-643.

Wike, E. L. and McNamara, H. J. A quest for the generalized conditioned reinforcer. Psychological Reports, 1955, 1, 83-91.

Winer, B. J. Statistical principles in experimental design. 1962, New York: McGraw Hill.

Wunderlich, R. A. Strength of a generalized conditioned reinforcer as a function of variability of reward. Journal of Experimental Psychology, 1961, 62, 409-415.

Zimmerman, D. W. Durable secondary reinforcement: Method and Theory. Psychological Review, 1957, 64, 373-383.

Zimmerman, D. W. Meanwhile...back at the key: Maintenance of behavior by conditioned reinforcement and response independent primary reinforcement. in D. P. Hendry's Conditioned Reinforcement. 1969, Homewood, Illinois: Dorsey Press, 91-124.