

THE FUNCTIONAL PROPERTIES
OF A CONDITIONED CUE

by

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ABSTRACT

The present thesis consists of two experiments designed to answer questions raised in a study by Marx and Murphy (1961). Experiment I studied the question whether discriminative training was necessary for establishing an effective secondary motivator. Two groups of rats experienced differential food-buzzer exposure on Days 1-3 of the experiment. For one group, food and buzzer were always paired; this pairing of food and buzzer was merely temporal, devoid of any intervening discriminative training. For the other group, food and buzzer were never paired. On Days 4-5, all Ss were given acquisition training of a simple runway response. The buzzer was absent during runway acquisition. On Day 6, Ss were tested for resistance to extinction. The buzzer was introduced on the fifth extinction trial and every fifth trial thereafter. The results indicated no difference between groups, and were interpreted to mean that discriminative-training was necessary for establishing an effective secondary motivator.

Experiment II investigated the effects of the reinforcing properties of a conditioned cue on resistance to extinction. This was done in order to assess the justification of Marx and Murphy's suggestion to rename secondary reinforcers as secondary motivators. The experimental procedure of Experiment II was a replication of Experiment I with one major exception. During the test of resistance to extinction, the buzzer was sounded in the goalbox (GB).

The results indicated that the paired Ss were stronger in resistance to extinction. This finding demonstrated the effectiveness of the reinforcing properties of a conditioned cue on resistance to extinction.

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Taken together, all three experiments (Marx and Murphy, 1961 and the present experiments I and II) suggest that discriminative training is not necessary for establishing a secondary reinforcer but is necessary for establishing a secondary motivator.

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CHAPTER I
INTRODUCTION

The principle of secondary reinforcement holds that a stimulus can acquire reinforcing power when it is correlated with the occurrence of a reinforcing stimulus (Schoenfeld, Antonitis and Berish, 1950).

More specifically, Hull defines a secondary reinforcer as:

Corollary 2. A neutral receptor impulse which occurs repeatedly and consistently in close conjunction with a reinforcing state of affairs, whether primary or secondary, will itself acquire the power of acting as a reinforcing agent. (Hull, 1951, p. 28)

It should be noted that Hull's definition of secondary reinforcement requires that the relationship between "the neutral receptor impulse" and the "reinforcing state of affairs" be merely one of temporal contiguity. Skinner (1938, pp. 224-252), in contrast, asserts that secondary reinforcement effects occur only when a response is followed by a stimulus which functions as a positive discriminative stimulus (S^D) for some further response, such as eating. The Skinnerian position considers that discriminative training is required for establishing a stimulus as an effective secondary reinforcer. In discriminative training, the subject (S) learns to respond only in the presence of the given stimulus, since S is only rewarded if it responds in the presence of that given stimulus.

Certain experimenters do not think such selective reinforcement is necessary to establish a strong secondary reinforcer. Ratner (1956) performed an experiment in which a click immediately preceded the delivery of water during magazine training. During testing, all responses by

the experimental group produced the click while responses by the control group did not result in the click. Both lever presses and approaches to the dipper were recorded. A significant difference in the number of bar presses for the click (experimental) group and the no-click (control) group was obtained. But there was little difference in the number of goal approaching responses or in the number of bar presses followed by goal approaching responses. It is possible that dipper-approach was reinforcing as well as the click. But if hearing the click was a secondary reinforcement, one would expect less dipper-approach since S would already have received secondary reinforcement. This would work to cancel the expected effect of more dipper-approaches by the experimental Ss. In general, the results suggest that a stimulus may be reinforcing although lacking discriminative properties.

Other studies supporting Ratner's (1956) findings have been reported by Ferster and Skinner (1957), Gollub (1958), Wyckoff, Sidowski and Chambliss (1958), Crowder, Hill, Hodge and Nash (1959), and Reynolds, Anderson and Bersch (1963). All of these studies have shown that it is possible to establish a stimulus as an effective secondary reinforcer in spite of the fact that the procedure did not involve discriminative training. However, certain experimenters argued otherwise. They have shown in turn, that discriminative training is a necessary and specific condition for establishing any measurable secondary reinforcing effect.

In support of the discriminative-stimulus hypothesis, Schoenfeld, Antonitis and Bersch (1950) ran the following study. They divided twenty male albino rats into experimental and control groups of ten rats each,

equated on the basis of operant lever activity for the last two of six days. They then conditioned these two groups of rats to press a lever by presenting food pellets after each lever-press. One hundred reinforcements were given each S, fifty on each of two days. For the experimental Ss, a light stimulus was correlated with each reinforcement. The light appeared for one second immediately after the food pellet was delivered, i.e., during the time that the rats would be eating the pellet. No light was presented to the control group. Following bar-press conditioning were four daily extinction sessions, each one hour long. For both experimental and control groups, bar depressions were unreinforced and in no case did the response produce the light. Such a procedure intervening between conditioning and test phases was designed "to reduce the strength of the response to a level where possible secondary reinforcing effects of the light could more easily be detected" (Schoenfeld et al, 1950, p. 41). The last phase of the study consisted of test sessions, each one hour long, given on two consecutive days. All Ss were unrewarded and every bar-press by animals of either group produced the one-second light. The groups did not differ in the number of responses emitted in the test sessions.

On the basis of their failure to demonstrate differences between the experimental and control groups, Schoenfeld et al (1950) concluded that the light in their experiment was not an effective secondary reinforcer. However, Cotton (1963) has pointed out that the Schoenfeld et al study lacked an essential control condition. He suggested that a third group which would receive light intervening between lever-pressing

and eating should have been run in order to demonstrate that ordinary secondary reinforcement effects would appear with the existing test conditions. Nevertheless, Schoenfeld et al's findings strongly suggest that secondary reinforcers must have positive discriminative stimulus properties to be effective. Subsequent studies by Notterman (1950) and McGuigan and Crockett (1958) have provided further support for Schoenfeld et al's (1950) original findings.

More recently Marx and Murphy (1961) ran a study employing the discrimination training procedure. Their study was designed to show the motivating properties of a cue which had been paired with primary reinforcement. Initially all subjects (Ss) were taught a head-poking response in the training box in order to obtain food pellets. Subsequent to the initial head-poke training, the experimental Ss and control Ss received different treatment. The experimental Ss were given discriminative training with a 5-second buzzer as the discriminative stimulus (S^D). Each S was placed in the training box for 15 seconds before the buzzer was sounded for five seconds. One food pellet was dropped into the food compartment of the training box accompanied by the buzzer sounding; it arrived approximately one second after the onset of the buzzer. Thus for the experimental Ss, food was always preceded by the 5-second buzzer. All experimental Ss received 30 presentations of food and buzzer pairings per day for three days. The control Ss had the same total of food and buzzer presentations, except food and buzzer were always separated by random intervals.

The second phase of Marx and Murphy's (1961) experiment consisted of runway acquisition training. All experimental and control Ss received identical treatment. They learned a simple runway response with continuous reinforcement. After two days of runway training, all Ss were given one day of massed extinction trials. For both groups, the 5-second buzzer was introduced on the 16th extinction trial and every 5th trial thereafter, with a minimum of 36 trials. The buzzer was sounded while the S was in the startbox (SB). At the end of the 5-second buzz, the SB door was raised immediately. By such experimental manipulations, Marx and Murphy intended to show the motivating effect of the secondary reinforcer (buzzer) on an instrumental activity (runway response) which had not previously been associated with the buzzer. The results showed that the experimental Ss were significantly more resistant to extinction than the control Ss. The experimenters attributed this greater resistance to extinction to the motivating properties of the effective buzzer cue. A subsequent study by McNamara and Paige (1962) supported the finding of Marx and Murphy's (1961) study.

Marx and Murphy (1961) had demonstrated clearly the motivating properties of the buzzer cue. They were able to do this through a particular procedural operation which eliminated the reinforcing properties of the cue. It is recalled that the buzzer cue was presented while S was still in the startbox, before the running response had been made. In other words, the cue was introduced before the running response rather than following it during extinction. Thus the experimenters were able to show the motivating properties of the buzzer cue.

Marx and Murphy had emphasized the use of that particular procedure in extinction in their experiment. They stated the rationale for it was to remove a confounded effect in a previous study by Estes (1948). Estes' (1948) study was very similar to Marx and Murphy's (1961) study in design. He showed that a tone previously associated with presentation of food would facilitate rate of bar-pressing during extinction when sounded in a Skinner box. However in that design, the tone sounded continuously for a time period during which a number of bar-presses were made. It was thus allowed to follow as well as precede the response, and the resulting increase in bar-presses might be interpreted in terms of the reinforcing properties of the stimulus as well as its motivating properties. Therefore in order to demonstrate unconfounded motivating properties of a conditioned cue, Marx and Murphy ensured that the cue only preceded the running response.

While Marx and Murphy's (1961) finding is interesting, their study raised certain questions; one of which was raised by themselves. They stated that it is not clear if the motivating effect obtained in their experiment was dependent upon the animal's head-poking response. They suggested that this question would be answered by experimental tests where the intermediary head-poking response was omitted during associative training of reward (food) and cue. They believe that such a test would determine and demonstrate purer motivational effects (Marx and Murphy, 1961, p. 210).

The present experiment was designed to clarify the above issue. It should be recalled that Schoenfeld et al (1950) stressed the

importance of discriminative training in establishing any effective secondary reinforcer. This emphasis on the necessity of discriminative training in the establishment of secondary reinforcers resulted in the formulation of the discriminative-stimulus hypothesis. A similar case could be made for the fact that discriminative training is necessary for the establishment of an effective secondary motivator. Thus the question that this experiment studied was "Is discriminative training necessary for establishing an effective secondary motivator?" According to the discriminative-stimulus hypothesis, discriminative training is considered necessary. However, according to the opponents of the discriminative-stimulus hypothesis, discriminative training is considered unnecessary. The present experiment was designed to test the predictions of these opposing views.

Experiment I was a replication of Marx and Murphy's (1961) study with one important procedural difference. During phase 1, the discriminative training procedure used in their study was replaced by a procedure in which the buzzer simply preceded the food reward. If the prediction of the discriminative-stimulus hypothesis were substantiated, there would be no difference in starting time and running time measures between the experimental and control groups. However, if the prediction of the opposing view were substantiated, there would be significant differences in starting and running time measures between the experimental and control groups.

METHOD

Subjects

The subjects (Ss) were 16 experimentally naive male rats purchased from the National Laboratories in Edmonton, Alberta. They were housed individually upon arrival at the laboratory of the University of Victoria from age 60 days. At the start of the experiment, Ss were 86-100 days old.

Apparatus

The apparatus, schematically shown in Fig. 1, consisted of a start-box, (SB), a closed runway and a goalbox, (GB). The SB measured 12 x 3 x 6 inches; the closed runway measured 35 x 3 x 6 inches; and the GB measured 14 x 4 x 6 inches. They were all painted mid-gray and covered with hinged lids of clear Plexiglas. At the end of the GB, on the external right side, there was a plastic chute, measuring $\frac{1}{4}$ inches in diameter, down which pellets could be dropped directly into a food-cup recessed in GB floor.

There were two lines which marked off starting and stopping points initiating the experimenter's operation of stop-watches. One line was drawn 12 inches from the rear wall of the SB. The other line was drawn 14 inches from the rear wall of the GB.

A 10 volt door buzzer, wrapped in felt was suspended about one foot below GB. The buzzer was powered by a 12 volt stepdown transformer, which in turn was connected to a Variac set at 40.

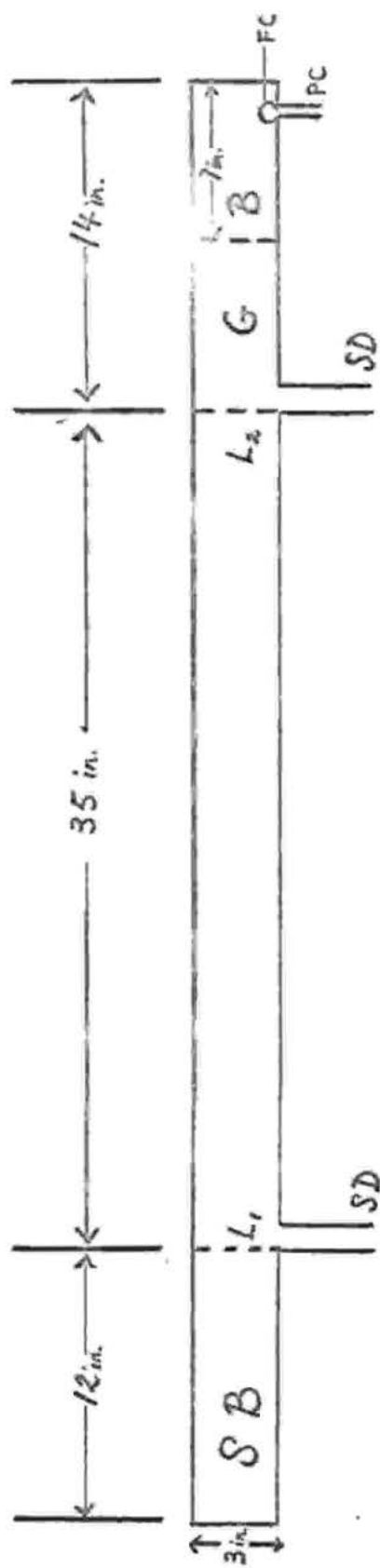



FIGURE 1. Schematic diagram of apparatus

KEY

- SD - Sliding door
- FC - Food-cup recessed in GB floor
- PC - Plastic chute
-  - Special GB partition for pre-training purposes
- L_1 - Line demarking termination of SB latency recording, when the S cleared it; and start of running time recording
- L_2 - Line demarking termination of running time when S cleared it

Procedure

Feeding schedule. All Ss were placed on a 23-hr. food-deprivation schedule for 14 days prior to the first day of experiment, and were given ad lib. access to water. They were also handled in groups of four for ten minutes per day. On the last two days of deprivation and handling, each S received 37 mg. Noyes pellets in home-cage. They were required to eat the pellets before getting their maintenance diet.

Food-buzzer exposure. With the exception of absence of discriminative training, the procedure followed closely that in Marx and Murphy's (1961) study. During food-buzzer exposure, part of the GB was sealed off to reduce its length. Consequently, the portion in which Ss were placed measured 7 inches in length. This procedure was adopted in order to restrict Ss' movements. On Days 1-3 of the experiment, each S was placed in the partitioned section of the GB. At the end of the daily session of food-buzzer exposure, the S was returned to its home-cage and fed ad lib. for 1 hour after a 60-minute delay.

The Ss were randomly assigned to two groups of 8 Ss each. They experienced differential food-buzzer exposure on Days 1-3 of the experiment. For one group, food and buzzer were always paired. For these Ss a 5-second buzzer always preceded food presentation, (Paired-SB). (SB stands for startbox. It denotes the buzzer locus in extinction.) Each paired presentation of food and buzzer was separated by an interval of 40, 45 or 50 seconds. The sequence of the intertrial intervals (I T I) was determined randomly with the restriction that the mean interval for each day was 45 seconds. All Ss received 30 pairings of food and buzzer per day for three days.

The other group of Ss received identical amount of food presentation and buzzer exposure except that food and buzzer were never paired, (Unpaired-SB). For these Ss, food and buzzer presentations were separated each by random intervals of 20, 25 or 30 seconds, with a mean of 25 seconds each day.

Acquisition. On Days 4-5, all Ss received identical training in runway acquisition. Each S received two preliminary exploratory trials and 10 regular training trials per day for two days. During the first two preliminary trials, sliding doors of the SB and GB were opened. For each of these preliminary exploratory trials, five 37 mg. Noyes pellets were put in the recessed food-cup. Each S was placed in the SB, allowed to explore the runway and to encounter the food pellets in the GB. If S did not explore the entire runway, E gently pushed it into the unexplored areas. Five minutes after the second pre-training trial, S was given the regular runway trials, with two 37 mg. Noyes pellets as reward for each trial. On a regular trial, S spent 15 seconds in the SB, then the SB door was opened. The SB door was closed behind S, to prevent retracing. The S was confined in the GB for 20 seconds before being returned to an I T I retaining cage for another 20 seconds. One hour ad lib. feeding in home-cage was provided 1 hour after each day's trials. The buzzer was not presented throughout runway acquisition training.

Starting time and running time were both recorded by stop-watches. The first stop-watch, recording SB latency, was started at the opening of the SB door. It was stopped when S cleared the line which was 12 inches from the rear wall of SB. Simultaneously the second stop-watch, recording

running time, was started. This was stopped when S cleared the line which was 14 inches from the rear wall of GB.

Extinction. The test of resistance to extinction was given on Day 6. Each S was given a maximum of 36 massed extinction (non-rewarded) trials. Any S which did not enter GB within 90 seconds of leaving SB was placed in GB for 20 seconds, and was given a score of 90 seconds for that particular trial. Then S was returned to the SB at the end of the 20-second GB retention period. The Ss which failed to reach GB within 90 seconds on two successive trials were given a score of 90 seconds for the remaining trials on which they were not run. In extinction, each S spent 20 seconds in SB before the SB door was opened. The S was confined for 20 seconds in GB, after which it was returned to the SB.

The buzzer was introduced on the fifth extinction trial and was presented every fifth trial thereafter (i.e., on trials 10, 15, 20, 25, 30 and 35). The 5-second buzzer was sounded during the last five seconds of the 20-second SB detention period. The SB door was raised when the buzzer was stopped.

Starting time and running time were recorded as in acquisition. However in the actual data analysis, a test of the direct effect of the buzzer was made by comparing seven trial-pairs. Each trial-pair consisted of a buzzer trial and a pre-buzzer trial. A buzzer trial for all Ss was a trial on which a 5-second buzz preceded the opening of the SB door, (e.g., trial 5). A pre-buzzer trial was the trial preceding a buzzer trial. The buzzer remained silent on a pre-buzzer trial, (e.g., trial 4).

Experimental design. Two groups of 8 SS each experienced differential food-buzzer exposure on Days 1-3 of the experiment. For one group, food and buzzer were always paired; with buzzer preceding food by 5 seconds. For the other group, food and buzzer were never paired. On Days 4-5, all SS were given acquisition training of a simple runway response. The buzzer was absent during runway acquisition. On Day 6, SS were tested for resistance to extinction. The buzzer was introduced on the 5th extinction trial and every fifth trial thereafter.

The formal design of the experimental is factorial: 2x2x7, or Experience (Paired vs. Unpaired food-buzzer exposure)-by-Buzzer (buzzer trials vs. pre-buzzer trials)-by-Trial Pairs. (A trial-pair consisted of a buzzer trial and a pre-buzzer trial.)

Schematic Diagram of Experimental Design:

<u>Groups</u>	<u>N</u>	<u>Days 1-3</u>	<u>4-5</u>	<u>6</u>
Paired-SB	8	Paired food-buzzer presentations in GB, with food consumption.	Runway acquisition training. Buzzer absent.	Extinction. 36 massed trials per <u>S</u> . Buzzer locus in SB.
Unpaired-SB	8	Unpaired food buzzer presentations in GB.	Runway acquisition training. Buzzer absent.	Extinction. 36 massed trials per <u>S</u> . Buzzer locus in SB.

RESULTS

Two t-tests were run on acquisition data (starting time and running time). The variable analyzed in acquisition was Experience (Paired vs. Unpaired food-buzzer exposure).

Two analyses of variance were run on extinction data (starting time and running time). The variables analyzed in extinction were: Experience, Buzzer (buzzer vs. pre-buzzer trials) and Trial-Pairs. (A trial-pair consisted of a pre-buzzer trial and a buzzer trial.) A logarithmic transformation, $\log_{10}(X + 1)$ was applied to the raw scores.

Acquisition

Starting time. The results of the t-tests indicated no significant differences in the starting time of the two treatment groups. Table I presents the mean starting time of the two groups in acquisition and extinction. On the last day of acquisition, starting time means as shown in Table I were 0.341 seconds for the Paired-SB and 0.381 seconds for the Unpaired-SB Ss (t = 0.003, df = 14, p > .05).

Running time. The results of the t-test indicated no significant differences in the runway performance for the two groups. On the last day of acquisition, running time means were 0.285 seconds for the Paired-SB Ss and 0.272 seconds for the Unpaired-SB Ss (t = 0.141, df = 14, p > .05).

Resistance to extinction

Starting time. A summary of the analysis of the extinction starting time of Paired-SB and Unpaired-SB Ss is presented in Table VI in the

Appendix. The mean SE starting time scores of these two groups are plotted in Figure 2. In extinction, the Paired-SB Ss did not differ significantly from the Unpaired-SB Ss in starting time measure. Table I shows that the mean extinction starting time on pre-buzzer trials were 0.704 seconds for Paired-SB Ss and 0.721 seconds for Unpaired-SB Ss. The same table shows that starting time on buzzer trials was 0.700 seconds for Paired-SB Ss and 0.845 seconds for Unpaired-SB Ss. ($F < 1.00$)

The analysis also showed that all Ss ran slower and slower over successive extinction trial-pairs. The results showed a significant main effect of trial-pairs ($F = 6.75$, $df = 6/84$, $p < .005$). Apart from this, no reliable differences were found.

Running time. Table VII presents the summary of the analysis on the extinction running time of SB-Ss (see Appendix I). The results indicated no significant findings except the main effect of trial-pairs ($F = 8.83$, $df = 6/84$, $p < .01$). This significant result indicated all Ss were extinguishing over the seven successive trial-pairs.

Table I - Mean starting time for SB groups in acquisition and extinction.
 (Scores are transformed scores)

GROUPS	ACQUISITION	EXTINCTION	
		Pre-Buzzer Trials	Buzzer Trials
Paired-SB	0.341	0.704	0.700
Unpaired-SB	0.381	0.721	0.845

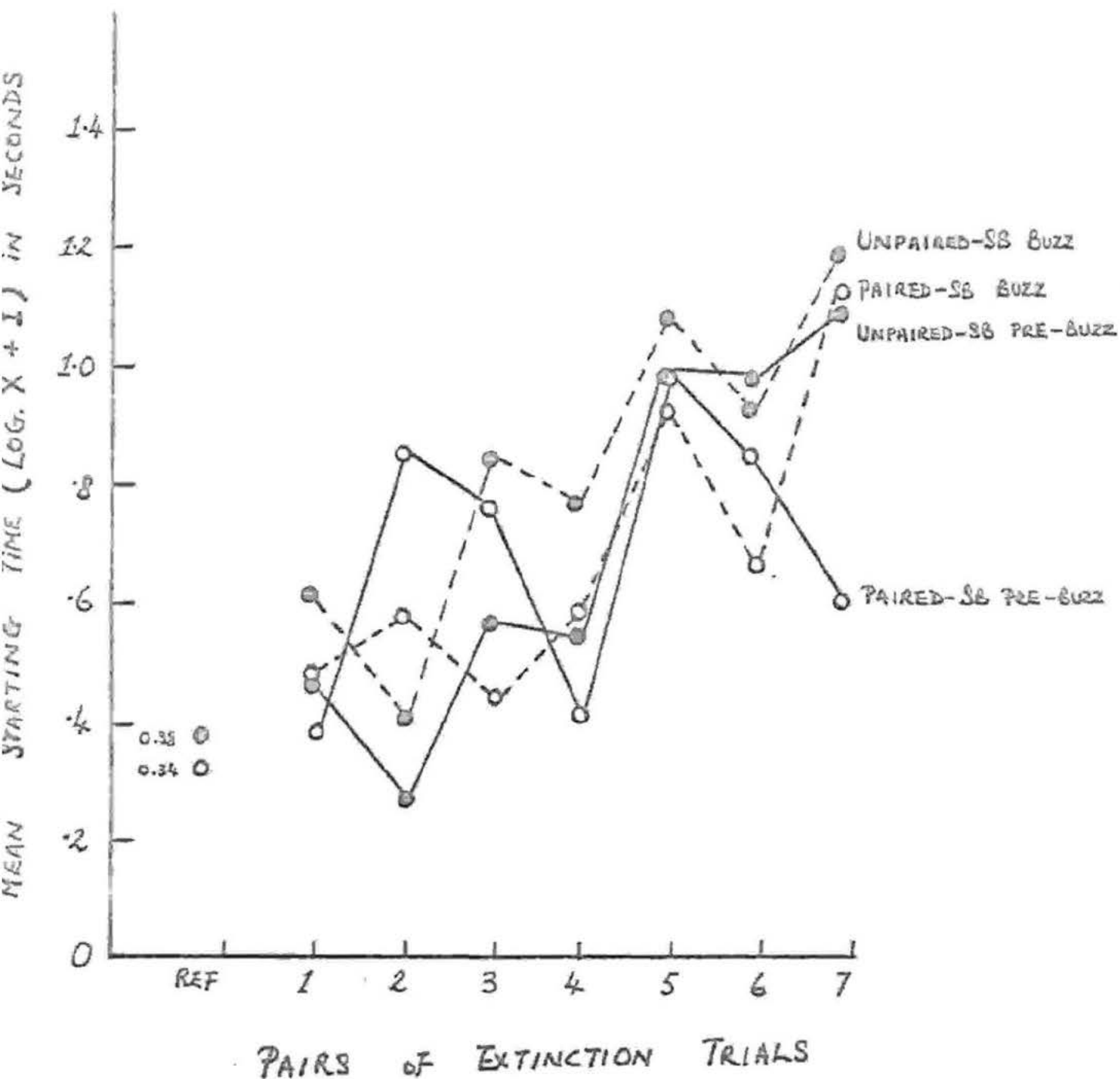


Fig. 2 Mean SB latency of Paired-SB and Unpaired-SB groups in extinction. (REF. refers to mean SB latency on the last acquisition day.)

DISCUSSION

The question studied by this experiment was "Will the motivating effects of a stimulus be demonstrated in the absence of discriminative training?" The answer given by the results of Experiment 1 was negative. The results of the present study indicated that the presentation of the buzzer cue while Ss were in the SB before the occurrence of the running response, had no effect on their subsequent resistance to extinction when compared with a control group. That is, Ss in the Paired-SB condition did not differ from those in the Unpaired-SB condition in the starting time or on running time measures during the extinction trials. Hence they were not consistent with Marx and Murphy's (1961) findings. Their data show that a cue paired with primary reinforcement increased the experimental group's resistance to extinction when this cue was presented before the running response occurred.

The failure to demonstrate a motivating effect of cues paired with primary reinforcement is believed to be the consequence of the conditioning training method used in the present experiment. It is recalled that Experiment 1 was a replication of Marx and Murphy's study with one major exception. The latter consisted of the procedural difference between the present study and Marx and Murphy's (1961) experiment in the conditioning of Ss in the Paired-SB group. Whereas Marx and Murphy required their Ss to exhibit a head-poking response while they were to associate the buzzer with food, the present study did not require Ss to perform this intermediary response. The training conditions of the present study merely required that there be temporal contiguity between the buzzer and the

presentation of food. This procedure was followed in order to test Marx and Murphy's suggestion that this test would determine the demonstration of purer motivational effects. It is quite obvious that no motivational effects were demonstrated with this procedure. This fact suggests that motivating effects of cues paired with reinforcement occur only when some form of discriminative training intervenes between the presence of the cue and the consumption of the primary reinforcer. Thus the results of Experiment 1 are taken to support the discriminative-stimulus hypothesis.

CHAPTER III
Experiment II
INTRODUCTION

It is recalled that Marx and Murphy emphasized "the motivating properties of a secondary reinforcer" in their study. Moreover, they concluded their study with the following remarks: "The extent to which secondary reinforcers generally can be shown to operate through such motivating properties . . . and thus perhaps should more properly be called secondary motivators . . . is an interesting and important question to which future research needs to be addressed." (Marx and Murphy, 1961, p. 209). The present experiment was designed to study the above question raised by those experimenters. It is observed that Marx and Murphy had not investigated the reinforcing properties of a conditioned cue in their experiment. They had not considered that the reinforcing properties of a conditioned cue might have similar effects on resistance to extinction, if such reinforcing properties had been investigated in their study. For this reason, the present experimenter considers the suggestion by Marx and Murphy to rename secondary reinforcers as secondary motivators to be premature. To resolve the question of the role of a conditioned cue as chiefly a motivator or reinforcer, the present experiment was run. Experiment II was designed to investigate the effects of the reinforcing properties of a conditioned cue on resistance to extinction.

Experiment II was a replication of Experiment I with two major procedural differences. These consisted of (a) onset of the cue and (b) buzzer locus in extinction. Both operations were designed to demonstrate the

effects of the reinforcing properties of the cue on resistance to extinction when such reinforcing properties were successfully isolated from the motivating properties. If secondary reinforcers operate chiefly through their motivating properties (as suggested by Marx and Murphy), then the effect of their reinforcing properties on resistance to extinction should be weak. Thus, the hypothesis of Experiment II states that there would be no difference in starting time and running time measures between experimental and control groups.

METHOD

Subjects and apparatus

The Ss were 16 experimentally naive male rats purchased from the National Laboratories in Edmonton, Alberta. They were from the same population as the Ss used in Experiment 1, and received identical housing treatment as the latter. At the start of the experiment, Ss were 86-100 days old. The apparatus was the same as in Experiment 1.

Procedure

With the exception of two major differences, the procedure here was identical to that in Experiment 1. The Ss were randomly assigned to two groups of 8 Ss each. They experienced differential food-buzzer exposure (Paired and Unpaired) on Days 1-3 of the experiment. They were given training in runway acquisition on Days 4-5 and on Day 6, they were tested for resistance to extinction. The first major procedural difference occurred in the food-buzzer exposure stage. For the 8 Paired Ss, the temporal onset of the buzzer was concomitant with food-consumption. (Paired-GB). (GB stands for goalbox. It denotes buzzer locus in

extinction.) The buzzer was terminated when eating stopped. For the remaining Ss, food and buzzer were never paired (Unpaired-GB). The second major procedural difference occurred in extinction. This was the locus of buzzer when it was introduced on the selected extinction trials. (Trials 5, 10, 15, 20, 25, 30, and 35.) The buzzer was sounded in the GB. Immediately after S had entered the GB and the GB door closed, the buzzer was sounded for the first 5 seconds of the 20-second GB. The starting time and running time in acquisition and extinction were recorded as in Experiment 1. However, in extinction the recordings were done on buzzer trials and post-buzzer trials. For all Ss, a buzzer trial was a trial with a 5-second buzz in the GB after the S had entered GB and was prevented from retracing by the closed GB door (e.g., trial 5). A post-buzzer trial was the trial immediately following the buzzer trial (e.g., trial 6). The test of direct effect of the buzzer during extinction was made by comparing seven trial-pairs, each of which was composed of a buzzer trial and a post-buzzer trial. The use of buzzer vs. post-buzzer trials to test the effect on resistance to extinction, instead of using buzzer vs. pre-buzzer trials as in Experiment 1, was necessitated by the purpose of the present experiment, viz., to investigate the effects of the reinforcing properties of the conditioned cue on resistance to extinction.

Experimental Design

Two groups of 8 Ss each experienced differential food-buzzer exposure on Days 1-3 of the experiment. For one group, food and buzzer were always paired; the onset of buzzer being concomitant with food-consumption and terminated when eating stopped. For the other group, food

and buzzer were never paired. On Days 4-5, all Ss were given acquisition training of a simple runway response. The buzzer was absent during runway acquisition. On Day 6, Ss were tested for resistance to extinction. The buzzer was introduced on the 5th extinction trial and every fifth trial thereafter.

The formal design of the experiment is factorial: 2x2x7, or Experience (Paired vs. Unpaired food-buzzer exposure)-by-Buzzer (buzzer trials vs. post-buzzer trials)-by-Trial-Pairs. (A trial-pair consisted of a buzzer trial and a post-buzzer trial.)

The possibility of trial effects confounded with treatment effects was tested in an analysis of variance. The results are summarized in Table IX (see Appendix I).

Schematic Diagram of Experimental Design:

<u>Groups</u>	<u>N</u>	<u>Days 1-3</u>	<u>4-5</u>	<u>6</u>
Paired-GB	8	Paired-food-buzzer presentations in GB, with food consumption.	Runway acquisition training. Buzzer absent.	Extinction. 36 massed trials per <u>S</u> . Buzzer locus in GB.
Unpaired-GB	8	Unpaired food buzzer presentations in GB.	Runway acquisition training. Buzzer absent.	Extinction. 36 massed trials per <u>S</u> . Buzzer locus in GB.

RESULTS AND DISCUSSION

Two t-tests were run on acquisition data (starting time and running time). The variable analyzed in acquisition was Experience (Paired vs. Unpaired food-buzzer exposure).

Two analyses of variance were run on extinction data (starting time and running time). The variables analyzed in extinction were: Experience, Buzzer (buzzer vs. post-buzzer trials) and Trial-Pairs. A logarithmic transformation, $\log_{10}(X + 1)$ was applied to the raw scores.

Acquisition

Starting time. The results of the t-test indicated no significant differences in the starting time of the two treatment groups. Table II presents the mean starting time of the two groups in acquisition and extinction. On the last day of acquisition, starting time means were 0.520 seconds for the Paired-GB group and 0.492 seconds for the Unpaired-GB group (t = 0.041, df = 14, p > .05).

Running time. The results of the t-test indicated no significant differences in the runway performance for the two groups. On the last day of acquisition, running time means were 0.296 seconds for the Paired-GB group, and 0.298 seconds for the Unpaired-GB group (t = 0.050, df = 14, p > .05).

Resistance to extinction

Starting time. A summary of the starting time analysis of the Paired-GB and Unpaired-GB groups is presented in Table III. The analysis of simple effects of the significant Experience x Buzzer interaction

is summarized in Table IV. The analysis of simple effects of the significant Experience x Trial-Pairs is summarized in Table V. The mean starting time scores of these two groups are plotted in Figure 3.

In extinction, Ss differed in starting time between buzzer and post-buzzer trials. The analysis indicated a significant buzzer main effect. ($F = 13.35$, $df = 1/14$, $p < .005$). The Ss ran slower on post-buzzer trials.

Moreover, the buzzer had differential effects on the Paired and Unpaired-GB Ss. The analysis indicated a significant Experience x Buzzer interaction. ($F = 9.15$, $df = 1/14$, $p < .01$). The buzzer increased significantly the starting time of the Unpaired-GB Ss on post-buzzer trials. The test of simple effect in Table IV showed a significant difference between buzzer and post-buzzer trials for the Unpaired-GB Ss, indicating significantly longer starting time on post-buzzer trials. ($F = 22.11$, $df = 1/14$, $p < .005$). But the buzzer did not have any apparent effect on the starting time of the Paired-GB Ss on post-buzzer trials. The test of simple effect showed a non-significant difference between buzzer and post-buzzer trials for Paired-GB Ss. ($F < 1.00$).

The Paired-GB Ss were also more resistant to extinction than Unpaired-GB Ss. They had faster starting times than Unpaired-GB Ss on both buzzer and post-buzzer trials. The test of simple effect indicated a significant difference in starting time between Paired-GB and Unpaired-GB Ss on buzzer trials, showing the Paired-GB Ss had significantly faster starting time on buzzer trials. ($F = 17.89$, $df = 1/14$, $p < .005$). The test of simple

effect also indicated a significant difference in starting time between Paired-GB and Unpaired-GB Ss on post-buzzer trials, showing the Paired-GB Ss had significantly faster starting time on post-buzzer trials.

($F = 81.08$, $df = 1/14$, $p < .005$).

All Ss ran significantly slower over the seven successive pairs of buzzer trials and post-buzzer trials. The analysis indicated a significant effect of trial-pairs ($F = 8.24$, $df = 6/84$, $p < .005$). Moreover, the significant interaction of Experience x Trial-Pairs ($F = 2.99$, $df = 6/84$, $p < .01$), indicated that this trial-pair effect was different for the Paired and Unpaired groups.

The results from the test of simple effect showed that the difference in extinction rate over successive trial-pairs was non-significant for the Paired-GB Ss, ($F = 1.90$, $df = 6/84$, $p > .05$). However this difference in extinction rate over successive trial-pairs was significant for the Unpaired-GB Ss, ($F = 9.33$, $df = 6/84$, $p < .01$). The above finding indicates that the Unpaired-GB Ss ran significantly slower over the successive trial-pairs, but the same does not hold for the Paired-GB Ss. Thus, the paired-GB Ss were more resistant to extinction than the Unpaired-GB Ss.

Running time. Table VIII presents the summary of the analysis on the extinction running time of SB-Ss. The results indicated no significant findings except the main effect of trial pairs. ($F = 14.51$, $df = 6/84$, $p < .005$). This significant result indicated all Ss were extinguishing over the seven successive trial-pairs.

Table II - Mean starting time for the GB groups in acquisition and extinction. (Scores are transformed scores.)

GROUPS	ACQUISITION	EXTINCTION	
		Buzzer Trials	Post-Buzzer Trials
Paired-GB	0.520	0.883	0.899
Unpaired-GB	0.492	1.037	1.208

Table III. A summary of the analysis of the extinction SB latency of the GB groups.

Source of Variation	df	MS	F
Experience (Paired vs. Unpaired Food-buzzer exposure)	1	2.998	< 1
Error (a)	14	4.349	
Buzzer (Buzzer vs. post-buzzer trials)	1	0.490	13.35 ***
Experience x Buzzer	1	0.336	9.15 **
Error (b)	14	0.037	
Trials - Pairs	6	1.601	8.24 **
Experience x Trial - Pairs	6	0.581	2.99 **
Error (c)	84	0.194	
Buzzer x Trial - Pairs	6	0.060	< 1
Buzzer x Experience x Trial - Pairs	6	0.112	< 1
Error (d)	84	0.117	
Total	223		

** $p < .01$

*** $p < .005$

Table IV. A summary of the analysis of variance of the simple effects in the significant Experience x Buzzer Interaction.

Source of Variation	df	MS	F
Experience on buzzer trials	1	0.662	17.89***
Experience on post-buzzer trials	1	2.679	81.08***
Buzzer for Paired-GB <u>Ss</u>	1	0.005	<1
Buzzer for Unpaired-GB <u>Ss</u>	1	0.818	22.11***
Error (b)	14	0.037	

*** $p < .005$

Table V. A summary of the analysis of variance of the simple effects in the significant Experience x Trial-Pairs Interaction.

Source of Variation	df	MS	F
Trial - Pairs for Paired - GB <u>Sa</u>	6	0.369	1.90
Trial - Pairs for Unpaired - GB <u>Sa</u>	6	1.810	9.33**
Error	84	0.194	

**p < .01

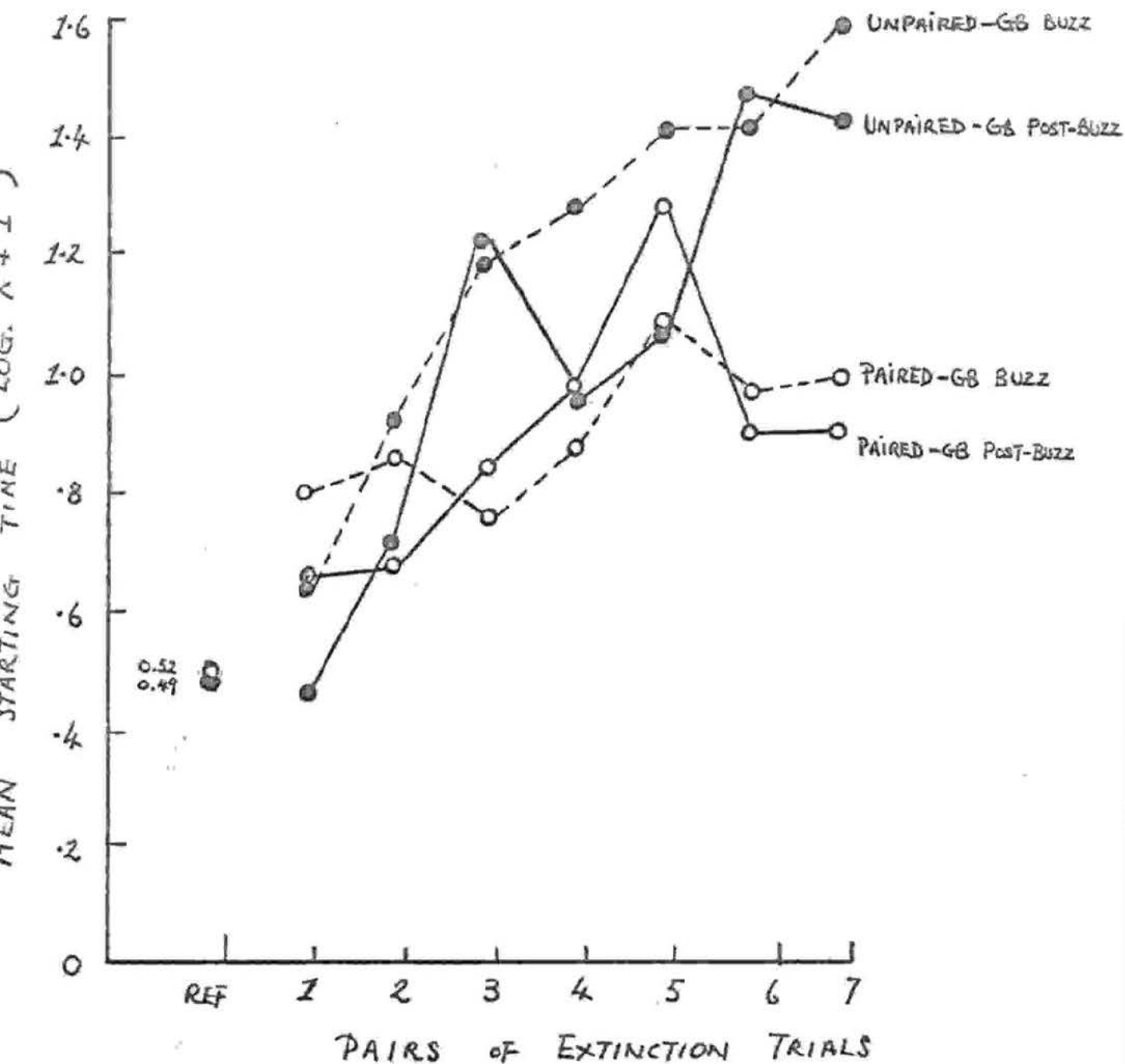


Fig. 3 Mean SB latency of Paired-GB and Unpaired-GB groups in extinction. (REF. refers to mean SB latency on the last acquisition day.)

The findings of the present experiment do not support the stated hypothesis that there would be no difference in resistance to extinction between the Paired-GB Ss and the Unpaired-GB Ss. The Paired-GB Ss were more resistant to extinction than the Unpaired-GB Ss. This finding is interesting when one considers the ineffectiveness of the conditioned cue (buzzer). It is recalled that the buzzer did not facilitate faster starting time of the Paired-GB Ss. The latter's starting time on post-buzzer trials did not differ significantly from their starting time on buzzer trials. Thus, the finding of stronger resistance to extinction of Paired-GB Ss suggests the following interpretation. Despite the absence of any apparently facilitative effect, the conditioned cue was able to maintain the Paired-GB Ss' level of resistance to extinction.

The finding that Unpaired-GB Ss showed longer starting time over post-buzzer trials than they did over buzzer trials, suggests the conditioned cue (buzzer) had a retarding effect on these Ss. This finding is unusual because the buzzer was not expected to have any effect, either facilitative or retarding, on these control Ss. Moreover, the retarding effect of the buzzer cannot be attributed to the startle-response for two reasons. First, the chosen tone of the buzzer did not elicit fear as shown in a pilot study. Secondly, Ss had been acquainted with the buzzer during three daily sessions of food-buzzer exposure, except that food-presentation was never contingent on the buzzer.

The present experimenter offers two possible explanations for the above finding. One explanation concerns the cue value of the buzzer. It

may be that over the successive extinction trials, the buzzer had come to serve as a cue of non-reward in the GB for these control Ss. The Ss came to discern the association between the buzz and the empty GB. Hence, the cue retarded their starting time on the subsequent trial (post-buzzer trial).

In brief, a cognitive approach seems to offer a possible account for the data found here, one that is similar to the discrimination hypothesis. Bitterman, Feddersen and Tyler (1953) presented reward in an end-box and non-reward in a distinctly different one to rats during acquisition. One group was subsequently extinguished with the rewarded end-box present and another group was extinguished with the non-rewarded end-box. It was assumed that stimulus situation from acquisition to extinction would be more similar when the non-rewarded end-box was present than when the rewarded end-box was used. According to the discrimination theory, rate of extinction should be faster for the group which was extinguished in the previously reward-associated end-box. The predicted results were found and were interpreted in terms of the discrimination hypothesis.

It is possible that a similar cognitive-associative event has taken place with regards to the Ss in the Unpaired-GB condition. It could be that remaining in the empty GB for 15 seconds after the 5-second buzz gave these Ss ample exploratory opportunity, temporally associated with the buzz, which was denied the Ss extinguished in the Unpaired-SB condition. With the latter, the SB door was raised immediately after the 5-second buzz. It is observed that the Unpaired-SB Ss had

equal amount of GB retention time as the Unpaired-GB Ss. Therefore, the former had equal exploratory opportunities in the empty GB, as the latter. However, they did not have the temporal contiguity of buzzer and empty GB as the Unpaired-GB Ss. It is this temporal contiguity between the buzzer and the empty GB that enables a cognitive account for the slower starting time of the Unpaired-GB Ss on post-buzzer trials.

However, there is an alternative account for the slower starting time of Unpaired-GB Ss on post-buzzer trials. It is possible that the slower starting time measures of the Unpaired-GB Ss on the post-buzzer trials might be independent of the buzzer cue. It could be that all Ss (Paired and Unpaired-GB) were extinguishing consistently and progressively across the seven successive trial-pairs. If this were so, then Ss would run slower on post-buzzer trials than buzzer trials since the post-buzzer trials always followed buzzer trials. Hence, the faster extinction rate of Unpaired-GB Ss on post-buzzer trials could be a mere function of the temporal placement of post-buzzer trials. In this case, their extinction rate on post-buzzer trials would be independent of the buzzer cue.

In order to test the validity of these two explanations of the faster extinction rate of Unpaired-GB Ss on post-buzzer trials, an analysis of variance was run. The data analyzed consisted of seven extinction trial-pairs which had been used in the analysis of extinction starting time, together with seven trial-pairs each of which preceded a pair of buzzer and post-buzzer trials. For example, the first extinction trial-pair of buzzer and post-buzzer trials for all GB Ss were trials 5 and 6. The preceding

trial-pair consisted of extinction trials 3 and 4. The variables analyzed were Pairs (Preceding trial-pairs vs. Experimental trial-pairs); trials (first vs. second trials, e.g., trials 3 vs. 4 for the Preceding Trial-Pair; and trials 5 vs. 6 for the Experimental Trial-Pair); and replications. The formal factorial design was 2x2x8 or Pairs-by-Trials-by-Replications.

If the cognitive account of the faster extinction of the Unpaired GB Ss on post-buzzer trials were substantiated, the expected results would be a significant main effect on Pairs (Preceding trial-pairs vs. Experimental Trial-Pairs). This main effect of pairs would indicate the Unpaired-GB Ss had faster starting times on the preceding trial-pairs than on the experimental trial-pairs. Moreover, a significant Pairs x Trials interaction would be expected. (Trials consisted of first vs. second trials.) This interaction would be asymmetrical, indicating Ss had the longest starting time mean score on the second trials (post-buzzer trials) within the experimental trial-pairs.

However, if the alternative non-cognitive account were substantiated there would be no significant main effect of Pairs nor a significant Pairs x Trials interaction.

The results of the analysis supported the non-cognitive account for the faster extinction of the Unpaired-GB Ss on the post-buzzer trials. Table IX in the Appendix presents a summary of the analysis. However, it was found that 56% of the variance of scores could be accounted for by the eight Unpaired-GB Ss. Hence if sample size were increased and variance subsequently decreased, significant results could be obtained. The latter

would support the cognitive account of the faster extinction of the Unpaired-GB Ss. This point awaits clarification from future research.

The present results supporting a non-cognitive account of the faster extinction of Unpaired-GB Ss suggest the following. They suggest that the buzzer held no cognitive associations for the Unpaired-GB Ss, but rather, it had temporarily distracted the Ss, and it was this distraction that retarded significantly their starting time on the trial immediately following. The above interpretation seems feasible since these Ss should not be startled by the buzzer with which they had been acquainted and that as control Ss, they were expected to extinguish consistently and progressively across the seven trial-pairs.

CHAPTER IV

DISCUSSION AND SUMMARY

This chapter discusses a general observation common to Experiments I and II, and then summarizes the rationale and results of the two experiments.

It is observed that in both experiments the conditioned cue (buzzer) was ineffective in facilitating faster starting time either as a motivator or a reinforcer for the experimental Ss. Apart from the role of discriminative training, this ineffective conditioning could be related to the amount of primary reinforcement given on the pairings with the buzzer. It is known that stimuli that are simply paired with reinforcers also reinforce (Kelleher and Gollub, 1962, p. 593) but that devoid of the discriminative status, the effects of the secondary reinforcer would be weaker, and hence, less detectable (Wike, 1966, pp. 464-465). Moreover, amount of primary reinforcement might be an important variable in situations where only weak secondary reinforcing effects can be demonstrated (Kelleher and Gollub, 1962, p. 586). Thus, it is conceivable that if, instead of giving one pellet per trial during pre-training of buzzer as a cue, experimental Ss were to be given either two or three pellets, stronger secondary reinforcer conditioning could have been established. This point is worth considering since pellets used in the present experiment were very small in size and weight (37 mg. per pellet) and especially when experimental data exist which show that amount of reward is directly related to strength of secondary reinforcing effects (Butler and Thomas, 1958; D'Amato, 1965; Hall, 1951; Hopkins,

1955 and Lawson, 1957).

Experiment I was designed to study a question raised by Marx and Murphy in their (1961) study. The question was whether motivating properties of a conditioned cue could be demonstrated in the absence of a discriminative-training procedure. The answer to the question was negative. The results in Experiment I demonstrated no effect of the motivating properties of the cue on resistance to extinction. Therefore, Experiment I failed to replicate findings of Marx and Murphy's (1961) study. It is recalled that Experiment I was a replication of Marx and Murphy's experiment with the omission of discriminative training. Hence, it could be concluded that the failure to replicate Marx and Murphy's findings was due to the absence of the discriminative training procedure.

Experiment II studied a second question raised by Marx and Murphy in their (1961) study. The question was whether or not secondary reinforcers should be re-named as secondary motivators. Marx and Murphy suggested strongly re-naming secondary reinforcers as secondary motivators. Because they had not investigated the effects of the reinforcing properties of a secondary reinforcer on resistance to extinction, Marx and Murphy's suggestion may be premature. To resolve the issue, Experiment II was designed to investigate the effects of the reinforcing properties of a conditioned cue on resistance to extinction.

The results indicated that the Unpaired-GB Ss (control Ss) extinguished faster than the Paired-GB Ss (experimental Ss). This suggests the experimental Ss were more resistant to extinction. Hence,

the results showed the effectiveness of the reinforcing properties of a conditioned cue on resistance to extinction. For this reason, Marx and Murphy's suggestion to re-name secondary reinforcers as secondary motivators is considered premature. The findings of Experiment II do not support the opinion of Marx and Murphy.

There was an unexpected finding of the Unpaired-GB Ss' slower starting time on post-buzzer trials. This was found to be caused by a temporary distraction of these control Ss by the buzzer with which they had been acquainted during the experimental phase of food-buzzer exposure.

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APPENDIX I

Table VI. Analysis of variance of the starting time of the Paired-SB and Unpaired-SB groups

Source of variation	df	MS	F
Experience	1	0.367	< 1
Error (a)	14	1.240	
Buzzer (pre-buzzer vs. buzzer trials)	1	0.204	1.03
Experience x Buzzer	1	0.227	1.14
Error (b)	14	0.199	
Trial - Pairs	6	1.561	6.75 ***
Experience x Trial - Pairs effect	6	0.392	1.69
Error (c)	84	0.231	
Buzzer x Trial - Pairs	6	0.215	1.48
Buzzer x Experience x Trial - Pairs	6	0.128	1.51
Error (d)	84	0.145	
Total	223		

*** $p < .005$

Table VII. Summary of analysis of variance on extinction running time
of SB-Ss

Source of Variance	df	MS	F
Experience	1	0.039	< 1
Error (a)	14	0.918	
Buzzer (pre-buzzer vs. buzzer trials)	1	0.011	1
Experience x Buzzer	1	0.283	1.66
Error (b)	14	0.171	
Trial - Pairs	6	2.145	8.83 **
Experience x Trial - Pairs	6	0.158	1
Error (c)	84	0.243	
Buzzer x Trial - Pairs	6	0.227	1.02
Buzzer x Experience x Trial - Pairs	6	0.351	1.58
Error (d)	84	0.222	
Total	223		

** $p < .01$

Table VIII. Summary of analysis of variance on extinction running time of GB-Ss

Source of Variance	df	MS	F
Experience	1	3.598	1.09
Error (a)	14	3.304	
Buzzer (buzzer vs. post-buzzer trials)	1	0.064	< 1
Experience x Buzzer	1	0.057	< 1
Error (b)	14	0.082	
Trial - Pairs	6	2.235	14.51 ***
Experience x Trial - Pairs	6	0.258	1.68
Error (c)	84	0.154	
Buzzer x Trial - Pairs	6	0.115	< 1
Buzzer x Experience x Trial - Pairs	6	0.112	< 1
Error (d)	84	0.142	
Total	223		

$p < .005$

Table IX. Summary of analysis of variance of the extinction starting time of Unpaired-GB group on Preceding Trial-Pairs and Experimental Trial-Pairs.

Source of variation	df	MS	F
Subjects	7	0.755	
Pairs (Preceding Trial-Pairs vs. Experimental Trial-Pairs)	1	0.017	3.40
Error (a)	7	0.005	
Trials (First vs. second trials in a Trial-Pair)	1	0.006	<1
Error (b)	7	0.014	
Pairs x Trials	1	0.086	2.77
Error (c)	7	0.031	

APPENDIX II

RAW SCORES OF STARTING TIME IN EXTINCTION OF SB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-SB SsPre-buzzer
Trials

	4	9	14	19	24	29	34
S ₁	7.6	2.4	90.0	1.2	3.0	1.6	2.0
S ₂	0.1	2.4	0.4	0.2	1.6	1.8	1.6
S ₃	0.3	1.4	0.1	0.1	4.0	1.4	1.4
S ₄	1.2	10.6	21.4	8.4	90.0	90.0	90.0
S ₅	0.6	7.2	1.6	1.4	1.0	11.4	1.0
S ₆	0.1	90.0	2.0	1.4	90.0	0.2	0.2
S ₇	2.2	6.2	2.8	3.6	8.8	90.0	1.4
S ₈	5.6	5.0	15.4	2.2	17.0	2.2	5.6

Buzzer Trials

	5	10	15	20	25	30	35
S ₁	3.4	4.1	3.4	7.0	5.2	4.2	10.6
S ₂	1.0	0.2	0.2	2.4	2.4	1.8	4.6
S ₃	0.3	6.2	3.4	6.9	9.4	0.6	22.0
S ₄	2.2	25.8	2.4	0.6	90.0	90.0	90.0
S ₅	0.1	1.8	1.6	4.3	2.6	0.8	6.6
S ₆	15.4	0.8	2.6	0.4	1.0	0.3	90.0
S ₇	9.8	5.6	2.2	7.6	43.8	11.0	9.2
S ₈	0.2	0.6	0.8	1.8	5.2	2.2	0.6

Unpaired-SB SsPre-buzzer
Trials

	4	9	14	19	24	29	34
S ₉	0.2	0.8	4.0	4.4	8.0	34.8	0.6
S ₁₀	1.0	0.6	2.2	1.8	3.0	1.6	1.2
S ₁₁	0.8	0.6	7.4	2.2	22.8	11.6	90.0
S ₁₂	1.0	2.2	0.6	0.6	3.4	0.4	0.4
S ₁₃	1.4	1.6	2.8	7.8	8.0	90.0	15.4
S ₁₄	5.2	0.2	1.2	0.2	3.4	0.4	90.0
S ₁₅	8.8	0.2	0.1	3.6	6.4	6.2	12.4
S ₁₆	4.4	3.0	20.0	7.8	90.0	90.0	90.0

Buzzer Trials

	5	10	15	20	25	30	35
S ₉	1.0	1.4	3.6	5.2	12.8	1.0	1.6
S ₁₀	5.4	1.2	2.0	1.2	5.0	6.6	4.0
S ₁₁	2.2	0.8	14.8	3.4	27.8	4.0	27.2
S ₁₂	1.2	0.8	12.0	2.8	1.8	0.2	7.2
S ₁₃	1.0	1.6	2.4	5.8	15.6	10.0	26.0
S ₁₄	1.4	0.2	2.4	0.6	4.6	45.0	90.0
S ₁₅	90.0	3.6	11.6	90.0	5.2	6.6	6.8
S ₁₆	2.6	6.2	23.2	5.2	90.0	90.0	90.0

RAW SCORES OF STARTING TIME IN EXTINCTION OF GB-GROUPS
(RAW SCORES ARE THE TIME SCORES IN SECONDS)

Paired-GB Ss

Buzzer Trials	5	10	15	20	25	30	35
S ₁	0.9	2.4	2.0	4.0	10.4	0.6	0.8
S ₂	90.0	2.8	90.0	90.0	90.0	90.0	90.0
S ₃	1.6	0.8	3.4	0.6	7.0	0.6	2.0
S ₄	15.8	90.0	90.0	90.0	90.0	90.0	90.0
S ₅	2.6	0.2	0.2	5.4	0.4	0.4	0.4
S ₆	1.0	0.6	1.4	0.2	3.8	0.4	0.4
S ₇	0.2	0.6	2.4	7.4	34.2	2.2	0.8
S ₈	1.2	36.6	4.0	12.4	83.2	90.0	90.0

Post-Buzzer
Trials

	6	11	16	21	26	31	36
S ₁	4.4	15.0	0.6	3.2	7.0	1.4	2.2
S ₂	1.8	90.0	90.0	90.0	90.0	90.0	90.0
S ₃	1.6	1.2	0.6	0.4	4.2	0.6	0.8
S ₄	90.0	90.0	90.0	90.0	90.0	90.0	90.0
S ₅	1.4	0.4	0.2	0.1	3.4	5.0	3.6
S ₆	0.4	1.2	0.2	0.2	0.2	0.6	0.2
S ₇	9.0	0.4	6.6	2.6	13.4	1.8	2.0
S ₈	14.8	5.8	3.6	36.2	14.6	58.8	90.0

Unpaired-GB Ss

Buzzer Trials	5	10	15	20	25	30	35
S ₉	0.6	4.0	39.2	3.8	4.4	7.2	1.0
S ₁₀	0.4	8.0	3.4	2.8	2.4	4.4	1.0
S ₁₁	1.6	1.6	90.0	90.0	90.0	90.0	90.0
S ₁₂	7.6	4.2	6.4	42.8	90.0	90.0	90.0
S ₁₃	5.0	8.6	19.8	9.4	24.9	90.0	90.0
S ₁₄	2.5	4.7	26.1	21.5	30.4	53.3	53.1
S ₁₅	1.4	1.2	21.6	0.8	0.8	90.0	90.0
S ₁₆	1.0	5.4	2.6	0.6	0.4	1.2	10.0

Post-Buzzer
Trials

	6	11	16	21	26	31	36
S ₉	6.6	2.6	2.2	90.0	10.0	1.0	13.2
S ₁₀	2.8	1.0	6.4	2.6	5.4	4.2	2.6
S ₁₁	0.4	65.0	90.0	90.0	90.0	90.0	90.0
S ₁₂	9.0	7.8	90.0	90.0	90.0	90.0	90.0
S ₁₃	1.2	29.8	11.6	11.8	35.6	90.0	90.0
S ₁₄	4.3	15.9	32.6	41.5	37.2	52.9	57.2
S ₁₅	7.8	4.2	27.8	1.0	16.2	90.0	90.0
S ₁₆	2.0	1.0	0.4	5.2	13.2	5.4	24.6

RAW SCORES OF RUNNING TIME IN EXTINCTION OF SB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-SB Sa

Pre-Buzzer

Trials	4	9	14	19	24	29	34
S ₁	24.2	4.2	90.0	3.6	39.4	12.2	11.2
S ₂	0.8	1.0	1.4	5.6	82.2	2.4	1.6
S ₃	1.2	1.6	2.8	1.8	12.6	15.0	31.4
S ₄	1.4	1.4	1.6	25.6	90.0	90.0	90.0
S ₅	0.8	12.8	1.2	1.2	1.2	33.4	2.2
S ₆	1.8	90.0	1.4	1.6	90.0	1.6	1.4
S ₇	1.8	3.2	5.8	1.4	29.8	90.0	5.8
S ₈	6.4	5.8	1.2	1.6	19.2	1.8	1.4

Buzzer Trials

Trials	5	10	15	20	25	30	35
S ₁	3.4	30.0	3.6	6.8	7.4	21.6	7.2
S ₂	1.0	1.2	6.8	26.0	1.2	33.8	90.0
S ₃	1.2	1.8	1.0	1.8	7.8	4.6	8.0
S ₄	1.4	6.2	1.8	2.2	90.0	90.0	90.0
S ₅	1.6	2.2	1.2	1.0	1.2	1.2	24.8
S ₆	2.8	1.2	1.4	1.6	1.6	3.6	90.0
S ₇	3.0	9.8	27.8	6.0	37.8	11.4	7.1
S ₈	1.6	1.4	3.8	4.6	1.6	6.0	1.0

Unpaired-SB Sa

Pre-Buzzer

Trials	4	9	14	19	24	29	34
S ₉	1.0	0.8	1.8	2.2	2.8	2.2	17.5
S ₁₀	1.3	1.2	4.4	50.8	1.8	90.0	1.2
S ₁₁	1.2	4.0	1.2	1.6	89.0	90.0	90.0
S ₁₂	1.0	3.6	1.8	26.2	10.6	1.4	6.2
S ₁₃	0.8	1.0	15.8	3.0	5.3	90.0	1.3
S ₁₄	1.6	1.2	3.8	19.8	12.2	18.2	90.0
S ₁₅	1.2	1.2	0.9	1.2	1.0	3.6	1.2
S ₁₆	3.2	2.4	8.0	2.6	90.0	90.0	90.0

Buzzer Trials

Trials	5	10	15	20	25	30	35
S ₉	1.0	1.0	2.4	2.4	4.8	3.1	5.6
S ₁₀	1.2	11.8	1.8	2.0	4.4	41.6	2.8
S ₁₁	3.2	1.6	37.2	90.0	17.2	1.8	13.0
S ₁₂	1.0	1.0	5.4	3.8	4.0	7.2	1.4
S ₁₃	1.0	1.2	16.4	1.6	18.6	1.1	8.4
S ₁₄	1.4	9.8	10.4	5.4	16.8	60.0	90.0
S ₁₅	90.0	1.0	1.2	90.0	14.8	1.2	2.8
S ₁₆	3.6	43.2	84.6	2.1	90.0	90.0	90.0

RAW SCORES OF RUNNING TIME IN EXTINCTION OF GB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-GB Ss

Buzzer Trials	5	10	15	20	25	30	35
S ₁₇	0.8	0.8	1.0	1.0	3.4	2.2	6.0
S ₁₈	90.0	3.8	90.0	90.0	90.0	90.0	90.0
S ₁₉	2.4	1.2	1.6	1.4	1.6	3.4	3.6
S ₂₀	3.4	90.0	90.0	90.0	90.0	90.0	90.0
S ₂₁	1.2	1.8	1.8	24.8	1.4	2.8	2.8
S ₂₂	0.8	0.8	1.4	3.6	1.2	1.2	17.6
S ₂₃	1.0	1.2	1.6	3.6	15.8	11.4	4.8
S ₂₄	1.8	2.6	1.6	31.6	1.8	90.0	90.0

Post-Buzzer
Trials

	6	11	16	21	26	31	36
S ₁₇	1.2	1.0	0.8	1.2	1.2	2.2	3.4
S ₁₈	1.6	90.0	90.0	90.0	90.0	90.0	90.0
S ₁₉	1.2	12.6	1.4	4.4	1.4	3.8	1.2
S ₂₀	90.0	90.0	90.0	90.0	90.0	90.0	90.0
S ₂₁	1.0	1.8	1.4	1.7	1.8	26.6	9.4
S ₂₂	1.0	0.6	0.8	2.4	1.6	1.0	1.4
S ₂₃	1.1	6.2	12.4	3.4	3.8	4.6	1.6
S ₂₄	12.6	1.8	28.4	2.0	5.4	3.8	90.0

Unpaired-GB Ss

Buzzer Trials	5	10	15	20	25	30	35
S ₂₅	2.0	3.4	4.0	4.2	2.6	4.0	1.2
S ₂₆	0.8	13.4	1.8	5.8	16.6	15.0	1.0
S ₂₇	1.8	22.8	90.0	90.0	90.0	90.0	90.0
S ₂₈	6.2	2.4	21.4	6.4	90.0	90.0	90.0
S ₂₉	1.2	6.0	7.6	59.2	13.1	90.0	90.0
S ₃₀	3.6	1.8	38.8	2.8	19.4	90.0	90.0
S ₃₁	1.4	10.6	1.8	33.4	4.0	4.4	8.8
S ₃₂							

Post-Buzzer
Trials

	6	11	16	21	26	31	36
S ₂₅	8.2	3.6	16.0	90.0	3.8	1.6	3.2
S ₂₆	1.0	1.0	30.6	3.0	1.0	8.8	4.2
S ₂₇	6.8	32.2	90.0	90.0	90.0	90.0	90.0
S ₂₈	1.6	30.2	90.0	90.0	90.0	90.0	90.0
S ₂₉	1.2	2.0	4.0	16.4	20.2	90.0	90.0
S ₃₀	9.8	1.8	2.2	7.6	3.0	90.0	90.0
S ₃₁	1.4	2.8	5.2	13.2	6.8	62.8	4.8
S ₃₂	4.3	10.5	34.0	44.3	30.7	61.9	53.2

RAW SCORES OF STARTING TIME IN ACQUISITION OF SB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-SB Ss

Trials	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈
1	0.80	1.00	0.80	0.40	0.80	1.10	0.20	0.20
2	0.20	0.80	0.60	0.30	0.20	4.60	0.80	0.10
3	1.70	0.20	1.00	0.40	1.80	4.00	1.60	0.60
4	0.20	1.40	1.00	0.20	1.60	4.20	0.80	0.10
5	4.40	2.60	2.00	0.20	2.20	0.40	4.00	1.00
6	7.20	0.60	0.80	0.20	1.20	1.80	5.20	4.40
7	0.20	0.40	3.00	0.20	9.40	2.00	0.40	1.60
8	3.10	3.40	3.80	0.40	1.80	0.40	2.80	0.20
9	1.20	1.80	0.80	0.20	2.60	7.40	1.80	2.20
10	0.20	1.80	1.20	0.20	1.00	4.80	3.20	1.00

Unpaired-SB Ss

Trials	S ₉	S ₁₀	S ₁₁	S ₁₂	S ₁₃	S ₁₄	S ₁₅	S ₁₆
1	3.80	0.60	0.20	0.80	0.20	0.10	3.00	0.80
2	4.00	5.20	0.20	1.40	0.60	0.20	4.80	0.80
3	9.40	1.80	0.20	0.60	0.20	2.20	3.00	0.70
4	6.80	4.00	1.80	1.00	0.40	0.10	0.60	1.20
5	3.20	0.60	0.80	2.80	1.00	2.60	1.80	0.60
6	1.20	2.80	0.40	1.20	1.20	1.20	2.00	2.20
7	1.20	2.00	0.20	2.20	0.40	0.10	0.20	0.60
8	8.80	2.40	0.80	2.10	0.60	0.10	2.00	0.80
9	1.20	3.20	0.60	1.40	2.80	0.60	1.60	0.80
10	1.40	5.40	0.40	0.30	0.80	0.20	1.60	0.20

RAW SCORES OF RUNNING TIME IN ACQUISITION OF SB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-SB Sa

Trial	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈
1	1.40	1.40	1.80	1.60	1.40	3.00	0.80	0.80
2	1.20	1.20	1.60	1.80	1.40	2.20	1.00	1.20
3	1.20	1.20	1.20	1.60	1.00	2.10	0.80	1.00
4	1.20	1.40	1.20	1.40	1.40	1.60	0.80	1.00
5	1.00	1.20	1.40	1.80	1.00	1.60	0.80	1.00
6	1.20	1.00	1.20	1.20	1.00	1.80	1.00	1.00
7	1.00	1.20	1.40	1.20	1.20	2.00	1.00	1.20
8	1.10	1.20	1.20	1.40	1.00	1.40	1.10	1.00
9	1.20	1.20	0.80	1.40	1.20	1.80	0.80	1.20
10	1.20	1.20	1.00	1.60	1.20	1.70	0.80	1.00

Unpaired-SB SS

Trial	S ₉	S ₁₀	S ₁₁	S ₁₂	S ₁₃	S ₁₄	S ₁₅	S ₁₆
1	1.80	1.40	1.30	1.20	1.20	1.50	1.40	1.00
2	2.10	1.40	1.00	1.00	0.80	1.00	1.80	1.40
3	1.40	1.40	1.00	1.00	1.00	1.20	1.20	1.20
4	1.80	1.00	1.20	1.20	1.20	1.10	1.40	1.40
5	1.60	1.20	1.20	1.00	1.10	1.00	1.20	0.80
6	1.00	1.20	1.20	1.00	1.20	1.00	1.20	1.20
7	1.20	1.20	1.40	0.80	1.00	1.20	1.00	0.80
8	1.40	1.20	1.20	1.20	1.20	0.80	1.20	1.00
9	1.20	1.20	1.20	1.00	1.20	0.80	1.20	1.00
10	1.00	1.20	1.40	0.80	1.00	1.00	1.00	0.80

RAW SCORES OF STARTING TIME IN ACQUISITION OF GB-GROUPS
(RAW SCORES ARE TIME SCORES IN SECONDS)

Paired-GB Ss

Trials	S ₁₇	S ₁₈	S ₁₉	S ₂₀	S ₂₁	S ₂₂	S ₂₃	S ₂₄
1	2.60	3.20	2.60	3.20	2.00	1.40	5.60	0.40
2	5.20	0.20	0.40	2.10	7.80	0.90	1.00	1.00
3	2.40	0.20	0.40	1.80	37.40	0.80	0.80	1.00
4	1.60	0.80	0.40	1.40	10.30	3.40	1.80	1.20
5	1.00	0.20	0.40	1.20	41.60	1.80	0.60	2.40
6	8.60	5.00	0.40	1.20	1.20	1.60	0.80	4.60
7	1.80	0.20	0.80	0.20	0.40	5.80	2.20	1.60
8	1.40	3.80	2.20	2.80	0.20	5.40	3.80	1.60
9	20.20	0.80	1.20	0.40	1.20	0.80	0.80	2.00
10	4.80	0.20	1.00	2.80	0.20	0.90	2.00	1.20

Unpaired-GB Ss

Trials	S ₂₅	S ₂₆	S ₂₇	S ₂₈	S ₂₉	S ₃₀	S ₃₁	S ₃₂
1	0.80	0.10	2.00	6.00	1.20	0.80	4.00	2.10
2	2.40	0.10	1.40	1.80	1.40	0.40	4.60	1.70
3	4.20	0.10	20.20	9.80	1.20	0.80	1.80	5.40
4	1.20	0.20	15.20	3.40	2.20	0.80	1.00	3.40
5	1.40	0.40	4.00	1.00	4.60	1.20	1.40	2.00
6	1.10	0.10	9.20	0.80	0.80	3.00	0.40	2.20
7	0.60	0.10	9.80	1.60	5.20	1.00	1.80	2.90
8	1.20	0.20	0.80	9.80	2.00	5.80	0.80	2.90
9	0.60	0.60	6.80	0.60	4.60	1.40	1.80	2.30
10	4.40	5.80	5.60	12.00	1.40	1.00	1.60	4.10

RAW SCORES OF RUNNING TIME IN ACQUISITION OF GB-GROUPS
(RAW SCORES ARE THE SCORES IN SECONDS)

Paired-GB Ss

Trials	S ₁₇	S ₁₈	S ₁₉	S ₂₀	S ₂₁	S ₂₂	S ₂₃	S ₂₄
1	1.90	1.20	0.80	1.50	2.10	1.60	1.20	1.20
2	1.80	1.20	1.00	1.00	2.20	2.00	1.00	1.20
3	2.00	1.20	0.80	1.60	2.20	1.80	1.40	1.20
4	1.60	1.20	0.80	1.20	2.30	1.20	1.40	1.60
5	1.60	0.80	0.60	1.20	2.00	1.40	1.20	1.20
6	1.60	1.20	1.00	1.40	4.60	1.80	1.00	1.20
7	1.80	0.90	0.80	1.00	1.80	1.40	1.00	1.20
8	1.40	0.80	0.60	1.20	1.60	1.40	1.00	1.20
9	1.60	1.00	0.60	1.00	1.60	1.20	1.00	1.40
10	1.80	1.00	0.80	1.40	1.40	1.40	1.00	1.00

Unpaired-GB Ss

Trials	S ₂₅	S ₂₆	S ₂₇	S ₂₈	S ₂₉	S ₃₀	S ₃₁	S ₃₂
1	1.20	1.40	1.60	2.00	1.60	1.40	1.40	1.50
2	0.80	1.30	1.20	2.40	1.20	1.60	1.80	1.50
3	1.20	1.80	1.10	1.80	1.40	1.20	1.20	1.40
4	0.80	1.60	1.20	1.60	1.20	1.80	1.60	1.40
5	0.80	1.20	1.20	1.60	1.60	1.20	3.60	1.60
6	1.00	1.20	1.60	1.20	1.20	1.40	1.20	1.30
7	0.60	1.40	1.60	1.40	1.20	1.30	1.70	1.30
8	0.60	1.40	1.40	1.20	1.40	1.60	1.60	1.30
9	1.00	1.40	1.40	1.20	1.20	1.20	1.20	1.30
10	0.60	1.40	1.20	1.60	1.20	1.40	1.40	1.30

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