University of Rhode Island
DigitalCommons@URI

Open Access Master's Theses

1981

The Establishment of Conditioned Reinforcement in Rats: Information Value or Contiguity

Robert Stephen Harris
University of Rhode Island

Follow this and additional works at: https://digitalcommons.uri.edu/theses

Recommended Citation

Harris, Robert Stephen, "The Establishment of Conditioned Reinforcement in Rats: Information Value or Contiguity" (1981). *Open Access Master's Theses.* Paper 1613.
https://digitalcommons.uri.edu/theses/1613

This Thesis is brought to you for free and open access by DigitalCommons@URI. It has been accepted for inclusion in Open Access Master's Theses by an authorized administrator of DigitalCommons@URI. For more information, please contact digitalcommons@etal.uri.edu.

THE ESTABLISHMENT OF CONDITIONED REINFORCEMENT IN RATS: INFORMATION VALUE OR CONTIGUITY

BY

ROBERT STEPHEN HARRIS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN PSYCHOLOGY

UNIVERSITY OF RHODE ISLAND

1981

ABSTRACT

An experiment was performed to determine the relative efficacy of "predictive information value" and of temporal contiguity with a primary reinforcer (S^R) in establishing conditioned reinforcement value of previously neutral stimuli. Three different temporal patterns of pairs of neutral stimuli were presented both contiguously with non-response contingent primary reinforcement (experimental groups) and non-contiguously with primary reinforcement. Subsequently, the efficacy of these stimuli in reinforcing a new response (lever press) was assessed, both across pairs of stimuli and within each pair. Previous findings regarding the optimal temporal intervals between stimuli and between stimuli and reinforcement for maximum information value and maximum contiguity were utilized to allow discrimination between the predictions of the two models.

Forty-eight Sprague-Dawley adult male rats were trained with 210 non-contingent presentations of the neutral stimuli and the S^R over a period of five days. For half of the subjects, the stimuli and S^R were presented contiguously. The other half received the stimuli at random. Relative to presentation of the S^R, using a random control procedure.

Subjects were tested over a three day period in a two lever operant chamber with the neutral stimuli available on separate levers

contingent upon the lever press response. Daily testing trials lasted 30 minutes with each daily session being recorded in consecutive 5 minute segments.

The results were analyzed using two four-way ANOVA's with repeated measures across two factors, the first being number of responses across successive days of testing and the second number of responses across successive 5 minute segments of Day 1. In the first ANOVA, a significant main effect was indicated across daily testing sessions. A follow-up test indicated that responding occurred primarily during Day 1, with negligible responding during Days 2 and 3. No other significant main effects or interaction effects were found in the first analysis.

In the second ANOVA, a significant main effect was found for consecutive 5-minute testing segments, as well as a significant interaction between the experimental/control factor and the repeated measures S_1/S_2 factor. Follow-up tests indicated that greater responding occurred during the first two 5-minute segments and that control subjects responded more to the first stimulus than did experimental subjects. Further, experimental subjects in one stimulus pair showed a preference for S_2, while controls showed a preference for S_1. These results occurred, however, in the stimulus pair predicted to have the least optimal temporal arrangement for the establishment of a conditioned reinforcement effect.

Overall, the results did not provide adequate support for either a contiguity or information model. Possible problems of insensitivity

in the procedure with this traditionally weak phenomenon are discussed as well as the possibility that the true conditioned reinforcer may have been the pattern of both stimuli which was not presented in testing. Further research possibilities are discussed.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to several people who have assisted me in the completion of this research. Special thanks are extended to Paul Gallagher, without whose equal sharing of responsibility in constructing the experimental apparatus and running the subjects, I would no doubt still be gathering data. His conscientiousness and thoughtful suggestions well surpassed expectations of a fellow experimenter.

I would also like to thank Dr. Albert Silverstein, my major professor, for his assistance in the design and completion and this research. Further appreciation is extended to the remaining members of my committee--Dr. Nelson Smith, Dr. Wayne Velicer, Dr. James Prochaska, and Dr. James Loy--for their critically helpful suggestions.

Appreciation is also extended to William Zwick and Pamela Zappardino-Harris for their assistance with problems presented by the data analysis.

TABLE OF CONTENTS

PAGE

LIST OF TABLES

LIST OF FIGURES

THE ESTABLISHMENT OF CONDITIONED REINFORCEMENT IN RATS: INFORMATION VALUE OR CONTIGUITY

Few concepts have received as much attention as explanatory mechanisms within the field of learning as has that of conditioned or secondary reinforcement. Some stimuli appear to be, by their inherent nature, reinforcing and will in the absence of any prior experience increase the subsequent frequency of responses which they follow. Other stimuli seem to have little, if any, effect on behavior at the outset of their occurrence. Yet after a sufficient period of certain types of exposure, these stimuli seem to acquire the ability to affect behavior in ways similar to those stimuli requiring no prior experience. Those stimuli requiring some amount of exposure are referred to as conditioned or secondary reinforcers (S^r) while their counterparts are termed primary reinforcers (S^R).

Very little human behavior is under the direct control of primary reinforcers such as food or water. On the contrary, human behavior seems very greatly affected by such tangible stimuli as money and material possessions and intangibles in the form of praise, attention, and success. These stimuli are often assumed by learning theorists to be categorized under the heading of conditioned reinforcers. It is not surprising, therefore, that a large body of experimental and applied literature has been devoted to attempts to understand and explain the necessary and sufficient conditions by which conditioned reinforcers

are established and maintained.

Three major experimental paradigms have evolved in an effort to understand this function. The first approach historically is the extinction method (Bugelski, 1938). Subjects are trained on some instrumental task, either a discrete trial task or a free operant task, which is followed by a "neutral stimulus" paired with a primary reinforcer. A test phase is then introduced in which the previous task is no longer followed by primary reinforcement but continues to be followed by the previously neutral stimulus. After repeated pairing of the neutral stimulus (e.g., bell, click, tone, light, etc.) with the primary reinforcer, the formerly neutral stimulus is said to have become a conditioned reinforcer, provided the subsequent test phase yields results in the appropriate direction. A significant decrease in the rate of extinction from that of a control condition is interpreted as a positive conditioned reinforcement effect.

This paradigm has been criticized because of the fact that results originally attributable to conditioned reinforcement effects seem to be amenable to several equally plausible alternative explanations (Wike, 1966). While differential effects between experimental and control groups may be attributable to the previously neutral stimulus functioning as a conditioned reinforcer, it is also possible that effects are due to lesser stimulus generalization decrement within the experimental group (Wike, 1966) or greater arousal of general activity levels (Gilbert & Sturdivant, 1958) within experimental groups. Because of the inability of the paradigm to control for these alternative

explanations, this design has largely ceased to be employed.

A second approach incorporates a variety of procedures, the most frequently used of which are token designs and chained schedules (Wike, 1966; Kelleher & Gollub, 1962). These procedures may be referred to as maintenance tests, because of the fact that primary reinforcement remains available in the test phase. In token studies, for example, subjects are typically trained to use poker chips in some manner (e.g., to insert them into a vending machine (Wolfe, 1936)) to obtain primary reinforcement. A delay is then instituted in which subjects are required to accumulate tokens before exchanging them. Finally, in the test phase, subjects are required to perform a task in order to obtain the tokens as a means of assessing the conditioned reinforcing effectiveness of the tokens. Whereas in the extinction paradigm primary reinforcement was no longer available subsequent to the training phase, in the latter studies tokens earned during the test phase are exchangeable for primary reinforcement on either an immediate or delayed schedule.

In the chained schedule, subjects are required to perform in one component of a chain in order to obtain a stimulus (discriminative stimulus; S^D; S_1) under which appropriate responding will yield primary reinforcement. Responding in the first component of the chain is said to be attributable to the S^r functions of the S^D for the second component. Chained schedules may be homogeneous, i.e., they may involve the same response in different components of the chain, or heterogeneous, i.e., they may involve two or more different responses, one for each component of the chain. Proponents of the chained schedule

interpret token studies as examples of heterogeneous chains in which the last response in the chain is an exchange response (Kelleher & Gollub, 1962).

The major drawback of the paradigm stems from the confounding of both S^D and S^r functions within the stimulus of interest. For example, assume that a pigeon is key pecking on a FI 2-minute schedule in the presence of a red light. The termination of the first segment of the chain is signaled by the offset of the red light and the onset of a green light signalling that an FI 5-minute schedule is in effect, at the end of which the green light offsets and primary reinforcement is delivered. Proponents of chained procedures would regard the green light as the Sr maintaining responding in the first segment of the chain. However, it is impossible to examine the necessary and sufficient conditions for the establishment and maintenance of S^r effects at the same time a stimulus is functioning as S^D for responding in the subsequent segment. The use of a tandem chain in which neutral stimuli are omitted effectively controls for the effect of the stimulus in the chain. However, by removing the stimulus, discriminative stimulus and conditioned reinforcer effects are simultaneously removed. In addition, the continued presence of the SR at the end of the chain confounds the interpretation of an Sr effect.

The third paradigm is that of the new learning test (Wike, 1966). The training phase of this design may be identical to that of an extinction paradigm. The subject may be trained to perform a task which is followed by a neutral stimulus and a primary reinforcer or, on the

other hand, the stimulus complex (the neutral stimulus followed by the primary reinforcer) may be delivered non-contingently, i.e., the subject is fed on cue rather than contingent upon the performance of an operant. The unique feature of this paradigm, however, is that the animal is now given the opportunity to perform a task different from any he learned in the first phase of the experiment. The new task is followed by the previously neutral stimulus. Evidence of an increase in performance of the new task relative to an appropriate control is taken as support for conditioned reinforcement.

While this latter paradigm provides the least confounded test of S^r effects, a major drawback is nevertheless inherent, since the test phase proceeds in the absence of primary reinforcement. Thus, S^r strength, which is at best moderate at the outset, is continually weakening.

Perhaps the most striking problem that may be noted in a review of the literature, however, stems not from the paradigm chosen to examine the phenomenon, but rather from the lack of adequate attention to experimental controls across all paradigms. Bolles (1967) states that:

> There is probably no concept in all of psychology that is in such a state of disarray as the concept of secondary reinforcement (p. 368).

This "disarray" is attributable in large part to inattention to critical control issues. To this end, Wike (1966) devotes one chapter exclusively to a discussion of control procedures.

Among the control issues which are most critical are comparisons

which address the issue of alternative explanations of S^r effects (such as stimulus generalization decrement) and various alternative theoretical interpretations of the S^r phenomenon.

As a result of problems in identifying the most appropriate paradigm, and developing adequate controls to eliminate alternate explanations of experimental effects, little progress has been made in answering even the most basic questions regarding the conditioned reinforcement phenomenon. Consequently, we are left still asking the question, "What are the necessary and sufficient conditions for the establishment of conditioned reinforcer effects?"

Several theories have been developed with varying degrees of support. Skinner (1938) states that a stimulus may become a conditioned reinforcer if it functions as a discriminative stimulus. Keller and Schoenfeld (1950) have gone further to state that the establishment of a stimulus as an S^D is a necessary and sufficient condition for its becoming a conditioned reinforcer. Several studies bear favorably on this hypothesis, generally referred to as the discriminative stimulus hypothesis. Studies by Schoenfeld, Antonitis, and Bersh (1951) and Dinsmoor (1957) are typically cited within this context. It must be remembered, however, that these studies address only the issue of whether it is sufficient to establish a stimulus as an S^D in order for it to function as an S^r. It would appear from their results that this is in fact the case. While Schoenfeld, et al. compare their SD group with a group in which the neutral stimulus was temporally contiguous with food delivery, it is not clear that subjects in this latter group

discriminated the neutral stimulus. Therefore, the question, as to whether it is necessary for a stimulus to function as an SD in order for it to function as an Sr, has not been adequately addressed.

While several studies (Ratner, 1956; Ferster, 1953; Autor, 1969) might be offered as negative support for the latter, perhaps the first serious challenge to the discriminative stimulus hypothesis was the work of Stein (1958) with respect to the establishment of S^rs via electrical stimulation of the brain. Stein placed subjects in a two lever chamber and followed presses on one lever consistently with a tone (Phase I). No preferences were indicated for either lever. During the second phase of the experiment (Phase II), subjects were delivered paired presentations of the tone and electrical stimulation to the brain (ESB) in the absence of the levers. Tone onset preceded ESB by 0.5 sec. and terminated simultaneously with ESB offset after one second of tone presentation. Phase one conditions were then re-instated as a test of the newly acquired S^r effects of the tone (Phase III). Finally in the last phase of the experiment (Phase IV) ESB was made contingent upon the performance of the lever press response. The latter was a test of the primary reinforcer effects of ESB sites. Comparisons were made between Phase I and Phase III for those subjects who demonstrated SR effects in Phase IV. Preferences for the tone-contingent lever as well as increases in response rates were evident.

Some concern may be raised regarding Stein's procedure due to the lack of adequate attention to controls. Subjects not responding to the SR in the post-test phase (employed to assess SR effects) were employed

as controls for the physiological procedure. No controls appropriate to the Sr component of the procedure were employed e.g., random presentation of the tone relative to ESB in training followed by contingent presentation of the tone during testing.

However, while not well controlled, Stein's study does suggest the existence of conditioned reinforcer effects in the absence of discriminative stimulus functions. The tone did not precede or signal an operant or known respondent nor was any likely to have developed accidentally during the 0.5 second inter-stimulus interval (ISI). While the occurrence of responses during similar intervals has been observed (Pliskoff, Hawkins, & Wright, 1964) the phenomenon is somewhat rare and as such improbable (Kling & Schrier, 1972).

A second study by Crowder et al. (1972) provides additional difficulty for the SD theory of Sr. Using a model similar to Stein's, Crowder et al. placed animals in a single lever operant chamber for a 5 hour pre-training period, for the purpose of establishing baseline. Each response was followed by the presentation of a buzzer together with an infusion of 0.018 ml of saline. At the end of the 5 hour baseline period the bar was removed and subjects were presented non-contingently with 100 buzzer-morphine pairings.

Testing followed the next day, beginning at the same time as the original operant period. With the lever once again in the chamber, subjects were again delivered buzzer-saline pairs contingent upon barpressing. Animals were then given a second 5 hour test

period in which buzzer-morphine pairings were delivered contingent upon leverpressing. The latter session was used to delete subjects not responding to the morphine as an SR. Three groups of subjects, each receiving different doses of morphine, were used.

A significant increase in responding above baseline operant levels was found as well as a significant effect of magnitude of morphine. Like Stein's study, no S^r controls were used, therefore rendering the results somewhat inconclusive. However, a within-subjects effect comparable to that obtained by Stein was identified. In addition, attending to the criticism of Stein's work by Pliskoff et al., subjects in the Crowder et al. study were closely observed for the development of superstitious behavior in the presence of S^+/S^R pairings during training. No stereotyped behavior was observed.

In summary, it may be concluded that discriminative stimuli are often conditioned reinforcers, but the evidence also indicates that stimuli may acquire S^r properties by simple pairing with primary reinforcement. It is not necessary to establish a stimulus as an S^D in order to endow it with S^r [illegible]

reinforcer. If such were the case, "primary" or "S^R" rather than "S^r" would seem to be the more appropriate designation. Given then that contiguity is necessary, is it sufficient?

The work of Stein, as well as that of Crowder et al., would seem to indicate an answer in the affirmative. Egger and Miller (1962), however, have proposed that simple pairing is not sufficient. According to their information hypothesis, a stimulus must provide some information about the forthcoming S^R. An informative stimulus, i.e., one which precedes the delivery of a primary reinforcer and thereby predicts its occurrence (see S_1 in Condition A of Figure 1), will acquire S^r Strength, while a redundant stimulus, i.e., one which

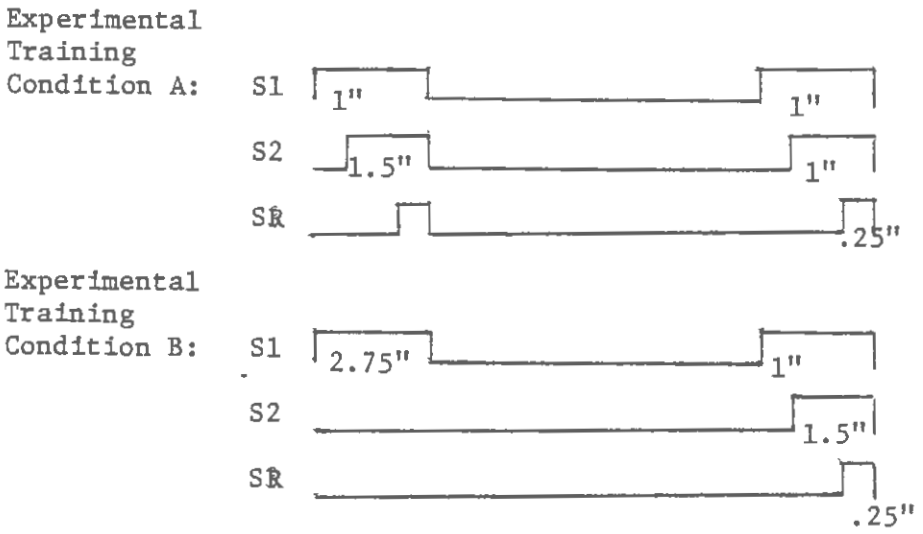
Insert Figure 1 about here

occurs subsequent to the onset of the first or informative stimulus but prior to the delivery of S^R (see S_2 in Condition A of Figure 1), thereby according to Egger and Miller, provides no new information which would enhance the predictability of S^Rs occurrence and thus would not acquire S^r strength. The same may be said for a reliable stimulus, i.e., one which consistently occurs immediately prior to the onset of S^R (see S_2 in Condition B of Figure 1) will acquire S^r strength, in contrast to an unreliable one, which occurs immediately prior to the onset of S^R but also occurs at other times unrelated to the delivery of S^R (see S_1 in Condition B of Figure 1).

Consider the stimulus configurations employed by Egger and

Figure Caption

Figure 1. Schematic diagram of stimulus configuration during the training phase of Egger and Miller's experiment (1"= 1 second). Condition A represents the experimental training configuration in which Stimulus 1 provides new reliable non-redundant information regarding the SR and Stimulus 2 redundant; Condition B represents the experimental training configuration in which Stimulus 2 is reliable, though redundant, and Stimulus 1 is unreliable (sometimes occurs in isolation).



S1 - Neutral stimulus (tone or flashing light)

S2 - Neutral stimulus (tone or flashing light)

SR - Primary reinforcer (food pellet)

Figure 1

Miller (see Figure 1). In condition A, S_2 is redundant. S_1 reliably predicts the occurrence of S^R and is presented prior to and simultaneously with S_2 in an overlapping configuration. According to the information hypothesis proposed by Egger and Miller, S_1 should function as the superior reinforcer.

In condition B, however, S_2 more reliably predicts the occurrence of S^R and is only redundant with alternate occurrences of S_1. S_2 can therefore be said to have greater informative value, and should function as the more effective reinforcer. Egger and Miller went on to say that S_2 in condition A, even though it has a more favorable position, in terms of a gradient of delay, will acquire little or no Sr value. While either of the former statements are compatible with a simple pairing approach, it is the latter that defines simple pairing as insufficient.

Egger and Miller's procedure involved the following phases: (1) subjects trained to barpress for food, (2) bar removed, and in the same box, S1 and S2 presented with food, (3) subjects retrained to barpress for food, (4) subjects extinguished, (5) subjects retrained to barpress for S1 or S2.

Egger and Miller's procedure employed three types of controls. One group of subjects, an "activation" control group, was trained using a yoked procedure in which stimuli were delivered contingent upon barpressing by the experimental subject to which each control subject was yoked. For these subjects, the bar was non-functional and barpressing was interpreted as an indication of the extent to

which the previously neutral stimuli "activated" barpressing.

Egger and Miller also employed a pseudoconditioned and unconditioned control group. Subjects in the pseudoconditioned group received the neutral stimuli in an explicitly unpaired procedure i.e., the neutral stimulus pair was presented randomly with the constraint that its presentation overlap at no point with the primary reinforcer. Unconditioned subjects received no food pellets at all during training. While these control procedures were substantially superior to those used in the typical Sr study, the most critical group, that group subjected to the pseudoconditioning procedure, was conceivably aversively conditioned to the neutral stimuli, (Rescorla, 1967) by virtue of the stimuli, S1 and S2, being explicitly paired with the absence of SR. Between group differences could therefore be attributed to the aversive conditioning of the control subjects rather than appetitive conditioning of the experimental subjects. In addition, it should be noted that control comparisons were tested separately from the overall analysis, therefore, increasing the likelihood of Type I error.

Despite these criticisms, however, it must be noted that Egger and Miller found, using a within subjects comparison, that responding to S1 was significantly greater than responding to S2 ($p<.001$).

The information hypothesis is not incompatible with a discriminative stimulus approach. As Hendry (1969) points out, the establishment of any discrimination generates informative stimuli. Hendry has

expanded upon the discriminative stimulus hypothesis and Egger and Miller's proposal with a more elaborate conceptualization of the information hypothesis. According to Hendry the essential role of an Sr is to reduce uncertainty regarding the subsequent occurrence of reinforcement or the performance of an operant. This is accomplished in two ways subsumed under two separate but related hypotheses.

The "clue hypothesis", as it is designated by Hendry, is similar to that of Egger and Miller, in which the essential function of the Sr is to provide the subject with clues signifying what subsequent stimuli to expect, i.e., to reliably predict the subsequent occurrence of established reinforcers. This approach is essentially a cognitive refinement and extension of a contiguity approach.

On the other hand, the "cue hypothesis", as it is identified by Hendry, states that the essential role of the Sr is to signal the subject as to what to do, i.e., to govern the ratio of the performance of an operant. This latter hypothesis requires a response contingent training procedure in order to establish the Sr's cue function.

According to Hendry, simple pairing and S^D training are insufficient for the establishment of an S^r. In order to function as an S^r, a stimulus must provide additional information. In support Hendry cites two predictions. First, stimuli associated with multiple schedules will function as S^rs so long as the multiple schedule remains in effect. This prediction is made by both S^D and

cue hypotheses. Secondly, stimuli associated with identical multiple schedule components will not function as S^rs. This prediction would not evolve from an S^D hypothesis as both stimuli are functioning as S^Ds for subsequent responding. The cue hypothesis, operating on the assumption that S^Ds must be informative with respect to differential responding in order to function as S^rs, would make the latter prediction.

Wyckoff (1969) in his work with observing responses observed that discriminative stimuli functioned as conditioned reinforcers in establishing and maintaining an observing response upon which the discriminative cues were contingent. Eliminating the discriminative function of the two cues, a "positive" cue signaling that SR was available and a "negative" cue signaling that no SR was available, was found to reduce the rate of the observing response to a relatively low value. Upon subsequent reversal of the original discriminative pattern, the observing response returned to a relatively high stable rate. While Egger and Miller's work implies a contiguity or S-S model, as indicated, the establishment of an uncertainty-reducing stimulus (Sr) via the development of an operant discrimination, as demonstrated by Wyckoff, follows an S-R model.

In summary, both the position outlined and supported by Egger and Miller (1962) and its extension by Hendry (1969), hypothesized that a stimulus must possess some informative value beyond simple contiguity and discriminative stimulus properties in order to function as an S^r. Before accepting such a position, several conflicting points

of evidence must be considered.

Bower, McLean and Meacham (1966) used a concurrent schedule design in which a multiple FI 10/40 schedule (i.e., discriminative cues were present for each FI pattern) of reinforcement was available on a right-hand response key with a mixed FI 10/FI 40 schedule (i.e., no discriminative cues for differential intervals were present) of reinforcement on the left-hand key. FI 10 and FI 40 schedules were programmed to occur an equal number of times in random sequence. Subjects indicated a preference for the multiple schedule key. As the multiple schedule provided more information, via differential S^Ds, regarding the availability of reinforcement, it would appear from this preliminary finding that a reduction in uncertainty is reinforcing, thus lending support to an information interpretation of the S^r phenomenon.

To further test this assumption, Bower et al. reduced uncertainty in both schedules by programming the FI 10 and FI 40 components in a 20%/80% balance respectively. Based on this reduction in uncertainty, the preference for the key associated with the multiple schedule should have had less informative value. The predicted result was that preference for the multiple key should be reduced. Such was not the case. A reduction in the uncertainty of the schedules did not reduce S^r effects. This analysis, however, places the major emphasis on the differential FI schedules themselves as the primary factor affecting

the reduction in uncertainty. Examining the nature of the discriminative stimuli from a more global perspective, however, requires attention to additional features in the sitmulus complex such as the color of the keys. A prediction based on a shift in uncertainty relative only to the extension of the ratio of schedule availability is confounded by the presence of these additional cues in the stimulus complex. Thus, Bower's findings are relatively inconclusive.

Bersh's (1951) study of the effect of delay of reinforcement upon S^r effects is also difficult to explain within an information hypothesis approach. Bersh delayed food presentation following light onset for 0, 0.5, 1, 2, 4, and 10 seconds. The light remained on until 2 seconds after the delivery of the food. In a new learning test Bersh then trained subjects to barpress for the light. The fact that the light remained on throughout the delay interval would indicate from an information hypothesis prediction that no differential effects should be found. In all cases, the light was the last non-redundant stimulus to occur before food presentation. In addition, it was reliable. Bersh, however, found differential S^r strengths among delay periods with 1 second being optimal. These results are difficult to justify within an information hypothesis approach. Adequate pseudo-conditioning controls were absent, however.

Further, the information hypothesis cannot account for the effect of magnitude of reward on S^r during training (Greene, 1953; D'Amato, 1955; Crowder at al., 1972). An information approach would say that magnitude or primary reinforcement should not affect the reliability

or informativeness of an S^r. This statement is difficult to reconcile with Wike's summary principle #2:

> 2. The strength of a secondary reinforcing stimulus varies directly with the amount of primary reinforcement (food) used during secondary reward training (Wike, 1966, p. 460).

Wike (1966) points out a final problem with the information approach with respect to his summary principles #4 and #5 which are as follows:

> 4. A stimulus which is paired with 100% of primary reinforcement in secondary reinforcement training, using the differential method, will have greater secondary reward value than a stimulus paired with partial primary reinforcement.
>
> 5. A stimulus which is paired with partial primary reinforcement in secondary reinforcement training, using the absolute method will have greater secondary reward value than a stimulus paired with 100% primary reinforcement.

As Wike indicated, the information hypothesis can account for principle #4. This in fact is similar to a within subject design using Egger and Miller's condition B (see Figure 1). Principle #5, on the other hand, is not as easily accounted for. Given equivalent training to two groups of subjects, the respective information values of partial and continuous pairing should be identical to principle #4, that is, the continuously paired stimulus should be a more reliable predictor of S^R than the partially paired stimulus. Assuming that Wike's principle #5 is correct (and several studies, while not well-controlled, are offered in support of principle #5 (Wike, 1966, p. 429-430), perhaps we are forced to conclude that the information hypothesis applies only in the case in which two distinctive stimuli are presented.

The information hypothesis proposes a point of view not incompatible with a contiguity hypothesis or a discriminative stimulus hypo-

thesis. Both paired stimuli and S^Ds are informative with respect to the forthcoming occurrence of S^R. As with the discriminative stimulus hypothesis, the establishment of information value in a stimulus would seem sufficient to endow a stimulus with S^r capacities. Likewise, it is not unreasonable to suppose that the more informative a stimulus is, generally, the more reinforcing it will be--at least in the case of the sequentially overlapping presentation of two differentially informative stimuli. However, to state that information value is necessary to the extent that a stimulus will reinforce only if it provides non-redundant or discriminative information is not supported by the available evidence.

The present study attempted to firmly establish an SR effect in a situation in which one can compare the relative efficacy of information value and contiguity as explanatory mechanisms. The study combines Bersh's (1951) design investigating the effect of delay of reinforcement upon Sr effects together with Egger and Miller's (1962) procedure employing sequentially overlapping stimuli. However, in contrast to the prior studies, the present design employs a control group for each experimental group. Each control was designed to permit the contrasting of contiguous pairing with random or non-contiguous presentation of the neutral stimuli and the SR: i.e., each experimental group was assessed against its appropriate control.

Both Bersh and Egger and Miller employed training phases in which the neutral stimuli and the primary reinforcer were paired and delivered in the absence of response contingencies. In order to replicate this aspect of both studies, and at the same time, avoid possible contamination

of the testing phase due to generalization effects of response contingent training, the present design employed non-response contingent training within a new learning paradigm. On the assumption that Egger and Miller's results are replicable, the following hypothesis and predictions are derived to allow for the limited generalizability of the information hypothesis while at the same time supporting the more general and more broadly applicable contiguity hypothesis. It is hypothesized that: The explanatory value of the information hypothesis of the establishment of conditioned reinforcement (as stated by Egger and Miller) is limited to the case wherein two optimally contiguous stimuli are presented in a sequentially overlapping manner. The contiguity hypothesis more parsimoniously accounts for Sr effects across the larger range of conditions identified for the establishment of said effects. The following predictions are derived from this hypothesis:

1. When two sequentially overlapping stimuli differ little in their optimal contiguity value, the first stimulus will acquire S^r strength. The second stimulus will acquire little if any S^r value.

2. When the second of two sequentially overlapping stimuli is optimally contiguous and the first is not, the second stimulus will acquire S^r strength. The first stimulus will acquire little if any S^r value.

3. When both the two sequentially overlapping stimuli are not optimally contiguous, neither will develop S^r strength.

METHOD

Subjects

Subjects were 48 experimentally naive adult male rats of the Sprague-Dawley strain, obtained from the Charles River Breeding Laboratories, whose mean weight at the outset of the study was 301.79 ± 41.50 grams.

Apparatus

All subjects were trained and tested in a Colbourne Instruments Model E10-10 Modular Small Animal Test Cage (lever box), housed in a light-proof and sound-deadened environmental chamber constructed in the U.R.I. psychology department laboratory. The box was lighted continually by a 28 volt incandescent House Light and the pair of lights housed in a Colbourne Instruments Model E14-06 Liquid Dipper/ Pellet Food Cup. The house light was centered directly above the food cup and both house light and food cup were centered on one wall of the lever box. The apparatus was automated by solid state and electro-mechanical programming equipment.

Procedure

All subjects were water deprived to 80% of their ad libitum weight and maintained at that weight throughout training and testing phases. The training-testing sequence extended over eight consecutive days with Days 1 through 5 being devoted to training and Days 6 through 8 being used for testing. During the training phase, all

subjects were placed in the lever box.

All subjects received 0.3 cc of sucrose solution in the food cup at the outset of training on Day 1, 0.1 cc on Days 2 and 3, and no sucrose solution at the outset of Days 4 and 5 of the five day training period.

During the training phase, all subjects received 210 presentations of a pair of sequentially overlapping neutral stimuli (an 80 decibel, 6000 cps tone and a 15 watt incandescent flashing (6 flashes/sec. light) and a 4 second dipper access to a 15% solution of sucrose and water. The sucrose/water solution was determined to be sufficient to motivate pilot animals, deprived to 80% of their ad libitum weight, to vigorously approach the food cup and engage in consummatory responding. Using a range of 4% to 32% concentration of sucrose and water, Guttman (1953) found the sucrose mixture sufficient to serve as an SR in the development of a new operant.

All subjects received 50 presentations of the stimuli on Day 1 of training and 40 presentations per day on Days 2 through 5.

All experimental subjects received "pairings" of the neutral stimuli overlapping with the sucrose solution at varied intervals over time, with intervals between paired stimulus presentations averaging 45 seconds (range, 15-75 seconds) for Days 1 and 2 of training and averaging 60 seconds (range, 15-105 seconds) for Days 3, 4, and 5.

All control subjects received presentations of the neutral stimuli at variable intervals identical to that of the experimental

subjects. Control subjects, however, received presentations of the sucrose solution at fixed intervals of 45 seconds for Days 1 and 2 and 60 seconds for Days 3, 4, and 5, following Rescorla's (1967) "truly random" procedure. While it is possible to regard this procedure as a case of temporal conditioning, initially to 45 second intervals of time and subsequently to 60 second intervals, the more important aspect of these groups was that of the random relationship between the SR and the neutral stimuli. The neutral stimuli in this configuration therefore bear no identifiable relationship to the SR, thereby virtually eliminating the establishment of an Sr effect within the stimulus pair.

No response was required of subjects during the training phase, i.e., presentation of the stimulus pair and sucrose solution was non response contingent.

Subjects were divided into three experimental groups, each with its corresponding control group for a total of six groups. Groups were divided according to the configuration of the neutral stimuli during training. Within experimental and control groups, the modality (tone versus light) was counterbalanced with respect to order of presentation.

Following the training format outlined above with respect to the variable interval presentation of neutral stimuli and primary reinforcer, Experimental Group I most closely matched Egger and Miller's (1962) study, with Stimulus 1 onset followed one second later by the onset of Stimulus 2, followed one second later by the delivery of the

sucrose solution, followed four seconds later by the simultaneous offset of S1 and S2 and the removal of the sucrose solution (S_1=6 sec; S_2= 5 sec; SR=4 sec). As indicated earlier, the corresponding control group differed in that the presentation of the neutral stimuli bore no predictable temporal relation to the delivery of the sucrose solution. The relationship between the presentation of the neutral stimuli exactly duplicated Experimental Group I.

Figure 2 illustrates the configuration of both groups.

Insert Figure 2 about here

Subjects in Experimental Group II received S_1, followed one second later by S_2, followed 9 seconds later by the delivery of the sucrose solution, followed four seconds later by the offset of S_1 and S_2 and the removal of the sucrose solution (S_1=14 sec; S_2=13 sec; SR=4 sec).

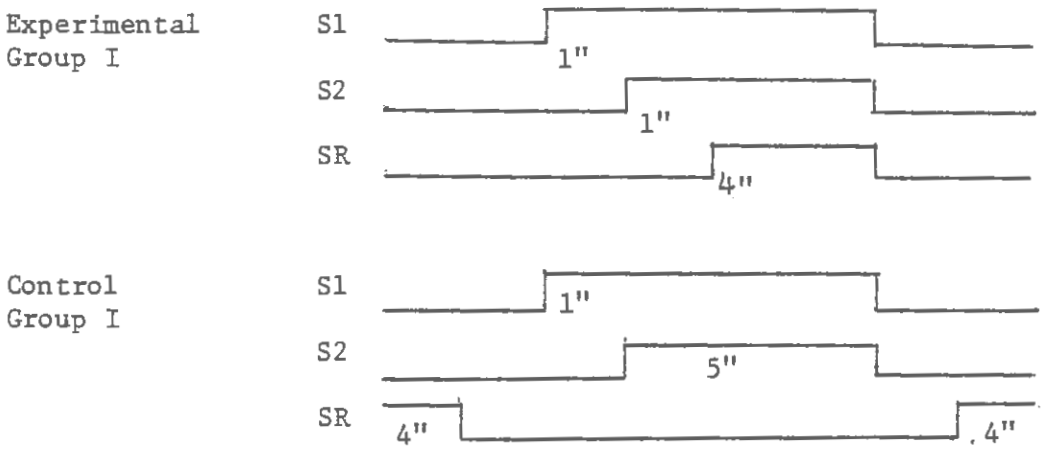
Control Group II, like Control Group I, matched the stimulus configuration of Experimental Group II, with the exception of the random relationship between the S_1/S_2 pair and S^R. Figure 3 illustrates the configuration of these groups.

Insert Figure 3 about here

Experimental Group III experienced the onset of S_1, followed nine seconds later by the onset of S_2, followed one second later by the delivery of sucrose followed four seconds later by the offset of S_1 and S_2 and the removal of sucrose (S_1=14 sec; S_2=5 sec; SR=4 sec). As with Control Groups I and II, the configuration of stimuli in Control Group

Figure Caption

Figure 2. Diagram of stimulus configurations for Experimental Group I and Control Group I (1" = 1 second). The experimental stimulus configuration (S1/S2/SR) is presented across a variable time interval. The control stimulus configuration (S1/S2) is presented randomly with the SR being delivered on a fixed schedule thus allowing for infrequent S1S2SR overlap.



S1 - Neutral stimulus (6 second delivery of tone or flashing light)

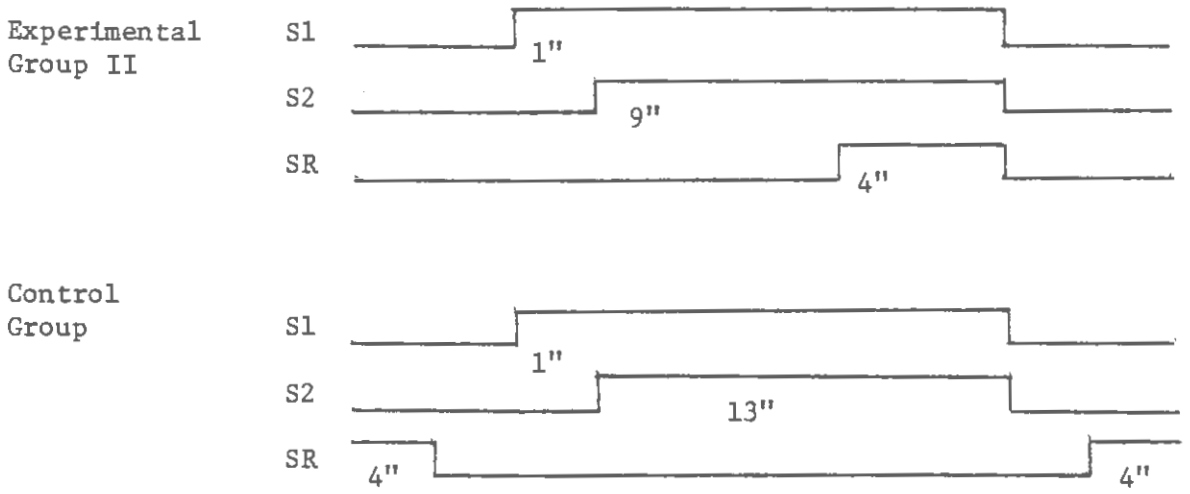
S2 - Neutral stimulus (5 second delivery of flashing light or tone)

SR - Primary reinforcer (4 second delivery of sucrose solution)

Figure 2

Figure Caption

Figure 3. Diagram of stimulus configurations for Experimental Group II and Control Group II (9" = 9 seconds). The experimental stimulus configuration (S1/S2/SR) is presented across a variable time interval. The control stimulus configuration (S1/S2) is presented randomly with the SR being delivered on a fixed schedule thus allowing for infrequent S1S2SR overlap.



S1 - Neutral stimulus (14 second delivery of tone or flashing light)

S2 - Neutral stimulus (13 second delivery of flashing light or tone)

SR - Primary reinforcer (4 second delivery of sucrose solution)

Figure 3.

III matched that of Experimental Group III with the exception of the random relationship between the S_1/S_2 pair and S^R. Figure 4 illustrates the configuration of these last two groups.

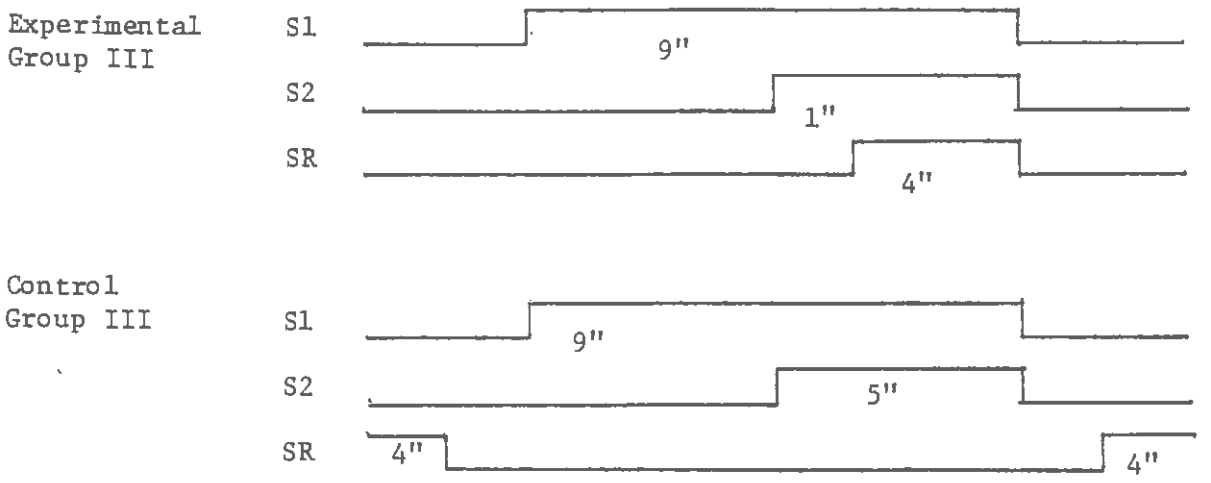
Insert Figure 4 about here

Following the training phase, two levers were introduced into the experimental chamber, one on either side of the food cup. Subjects were placed in the experimental chamber for one 30 minute session per day for three consecutive days (Days 6, 7, and 8 of the training/testing sequence.) Each 30 minute session was divided into six consecutive 5 minute sessions for the purpose of recording responses. Responding on one lever resulted in the one second presentation of S_1 while responding on the other resulted in the one second presentation of S_2. Stimuli were counterbalanced with respect to right-left lever position. Once established, the right-left lever position remained fixed throughout testing. Number of presses served as the dependent measure.

While it is often the case that studies will measure baseline operant levels of the response(s) of interest, for the purpose of a within subjects comparison of baseline and test results, this study did not include such a component. The primary reason for this omission was to negate the possibility of extinguishing, during baseline, exploratory behavior necessary for initial contact with the bar during testing, thereby attenuating, if not eliminating, any experimental affects. Additionally, it is important to note that because a within subjects preference procedure was used, any relationships obtained cannot be

Figure Caption

Figure 4. Diagram of stimulus configurations for Experimental Group III and Control Group III (1" = 1 second). The experimental stimulus configuration (S1S2SR) is presented across a variable time interval. The control stimulus configuration (S1/S2) is presented randomly with the SR being delivered on a fixed schedule thus allowing for infrequent S1S2SR overlap.



S1 - Neutral stimulus (14 second delivery of tone or flashing light)

S2 - Neutral stimulus (5 second delivery of flashing light or tone)

SR - Primary reinforcer (4 second delivery of sucrose solution)

Figure 4.

generalized to the between subjects case without explicit verification in that kind of paradigm.

RESULTS

A 3 X 2 X 2 X 3 ANOVA with repeated measures across the latter two factors was used to analyze the data across testing sessions. Factor A compared temporal arrangements of S_1 and S_2 (A_1, 6 sec., 5 sec.; A_2, 14 sec., 13 sec.; A_3, 14 sec., 5 sec.). Factor B compared experimental subjects receiving, in training, a presentation of the neutral stimuli paired with the sucrose solution, with control subjects receiving the neutral stimuli in a random relationship to the sucrose solution. Factor C, the first of the repeated measures factors, compared responding to receive S_1 during testing with responding to receive S_2. Factor D, compared mean responses across the three daily testing sessions.

Frequency of lever pressing was used as the dependent measure. (Means and standard deviations of this measure are represented in Appendix A.) Because of a significant violation of the assumption of homogeneity of variance (F_{max} (6,14) = 113.54, $p<.05$), the data was transformed using a $\log^{10}$ transformation to balance extreme values. (Reciprocal and square root transformations were found to be substantially less effective than $\log^{10}$ in reducing heterogeneity.) (Means and standard deviations of the $\log^{10}$ transformed data are represented in Appendix B.)

A test of the assumption of homogeneity of variance again resulted in a significant violation, F_{max} (6,14) = 30.87, $p<.05$. However, because the analysis of variance has been found to be relatively robust

with respect to moderate violations of the assumption of homogeneity (Box, 1953), the $\log^{10}$ transformation was considered to have sufficiently controlled for heterogeneity, so as to permit further analysis of the data.

The 4-way ANOVA of the transformed data resulted in a significant main effect for Factor D (daily training sessions), $F(2,84) = 21.93$, $p<.0001$. The ANOVA summary table for this analysis is shown in Table 1.

Insert Table 1 about here

Because no other significant main effects or interaction effects were indicated, the data were collapsed into the three levels of Factor D. A Newman-Keuls followup test (see Appendix C) was performed on the collapsed data in order to identify significant pair-wise differences across the three levels of D. Results indicated that responding on Day 1 of testing was significantly greater than responding on Days 2 and 3.

Because of the higher level of responding during Day 1 of testing, a second 4-way ANOVA was performed. Factors A, B, and C were identical to the first analysis. However, in this case, Factor D was a 4 level factor comparing the first four 5-minute segments of the first daily testing session. Because of low rates of responding in the latter segments of the testing session, it was concluded that the 30 minute test session had been unnecessarily long. This is not unexpected given the durability problems historically associated with Sr effects and the conservative procedure employed herein for the establishment of Sr

TABLE 1

Analysis of Variance
Summary Table

Source	SS	df	MS	F
Between Ss				
A	1.28739	2	0.64369	0.87
B	0.86156	1	0.86516	1.17
A x B	1.03150	2	0.51575	0.70
Error	31.16360	42	0.74199	
Within Ss				
C	0.02055	1	0.02055	0.14
A x C	0.14037	2	0.07018	0.49
B x C	0.13272	1	0.13272	0.92
A x B x C	0.07703	2	0.03851	0.27
Error	6.07279	42	0.14459	
D	7.03489	2	3.51744	21.93*
A x D	0.28196	4	0.07049	0.44
B x D	0.06729	2	0.03364	0.21
A x B x D	0.25577	4	0.06394	0.40
Error	13.47117	84	0.16037	
C x D	0.10700	2	0.05350	0.54
A x C x D	0.22538	4	0.05635	0.57
B x C x D	0.16128	2	0.08064	0.82
A x B x C x D	0.08797	4	0.02199	0.22
Error	8.25744	84	0.09830	

*$p < .001$

A - configuration (6 sec - 5 sec; 14 sec - 13 sec; 14 sec - 5 sec)

B - treatment (contiguous presentation (exp;) random presentation (cont.))

C - stimulus (stimulus 1; stimulus 2)

D - days (Day 1; Day 2; Day 3)

effects. It may be noted that Egger and Miller using a somewhat more robust "relearning" procedure eliminated from their analysis any testing beyond the first 15 minutes for each stimulus (each having been tested separately) finding that the majority of lever presses occurred during the first 2-4 minutes of the test session. Because extinction was relatively complete by the end of the fourth segment as indicated by zero response rates in one of the cells of both Segments 5 and 6, the latter were omitted from the analysis.

(Appendix D includes means and standard deviations of the raw data for the six segments of Day 1).

As in the previous analysis, it was necessary to perform a $\log^{10}$ transformation on the original data in order to reduce the violation of the assumption of homogeneity to within an acceptable range (F_{max} (6,21) = 6877.03, $p<.05$). (Means and standard deviations of the transformed data for Segments 1 through 6 of Day 1 are represented in Appendix E.)

A test of the assumption of homogeneity of variance again indicated a significant violation, F_{max} (6,21) = 14.40, $p<.05$. However, as in the previous analysis, the ANOVA was considered sufficiently robust with respect to a violation of this magnitude, to permit further data analysis. The ANOVA summary table for this analysis is shown in Table 2.

Insert Table 2 about here

A significant main effect of Factor D (5-minute segments) was identified, F (3,216) = 20.43, $p<.0001$, as well as a significant B

TABLE 2

Analysis of Variance
Summary Table

Source	SS	df	MS	F
Between Ss				
A	0.80708	2	0.4035	0.82
B	0.65042	1	0.65042	1.32
A x B	0.79049	2	0.39525	0.80
Error	20.63619	42	0.49134	
Within Ss				
C	0.00395	1	0.00395	0.02
A x C	0.09828	2	0.04914	0.26
B x C	0.90866	1	0.90866	4.73*
A x B x C	0.31134	2	0.15567	0.81
Error	8.07419	42	0.19224	
D	8.25173	3	2.75058	20.43**
A x D	1.00958	6	0.16826	1.25
B x D	1.01812	3	0.33937	2.52
A x B x D	0.51329	6	0.08555	0.64
Error	16.96379	126	0.13463	
C x D	0.20326	3	0.06775	0.50
A x C x D	1.08329	6	0.18040	1.32
B x C x D	0.32967	3	0.10989	0.80
A x B x C x D	0.66040	6	0.11007	0.81
Error	17.21934	126	0.13666	

*p<.05
**p<.0001

A - configuration (6 sec - 5 sec; 14 sec - 13 sec; 14 sec - 5 sec)

B - treatment (contiguous presentation (exp.); random presentation (cont.))

C - stimulus (stimulus 1; stimulus 2)

D - segments (Sec. 1; Seg. 2; Seg. 3; Seg. 4)

(experimental/control) by C (S1/S2) interaction, $F(1,42) = 4.73$, $p<.05$, i.e., while responses to Stimulus 2 were roughly equivalent for both experimental and control subjects, experimentals responded less to Stimulus 1, while controls responded more to the same stimulus. No other significant effects were indicated.

Because Factor D did not significantly interact with any other factors, cells were collapsed into a one-way analysis across the four 5-minute segments of Day 1 of testing. Means and Standard Deviations for this analysis are presented in Table 3.

Insert Table 3 about here

A Newman-Keuls follow-up test (see Appendix F) performed on this data indicated that responding in both Segment 1 and Segment 2 was significantly greater than responding in Segments 3 and 4. No other pairwise differences were indicated.

Graphs of the BC (treatment x stimulus) interaction at levels of B (treatment) represented in Figure 5, and at levels of C (stimulus) represented in Figure 6 indicated that simple main effects tests were necessary for both B at each level of C, and C at each level of B. The required BC (treatment x stimulus) summary table for the data from the second ANOVA is presented in Table 5.

Insert Figure 5 about here

TABLE 3

Means and Standard Deviations for Number of Lever Presses Collapsed Across All Factors for Segments 1, 2, 3, and 4 of Day 1 of Testing

Segment	1	2	3	4
$\overline{X}$	6.77	7.02	5.28	3.17
SD	7.98	18.64	19.36	7.77

Figure Caption

Figure 5. Graph of BC (treatment x stimulus) interaction at levels of B (treatment) across all subjects for Segments 1, 2, 3, and 4 of Day 1 of testing.

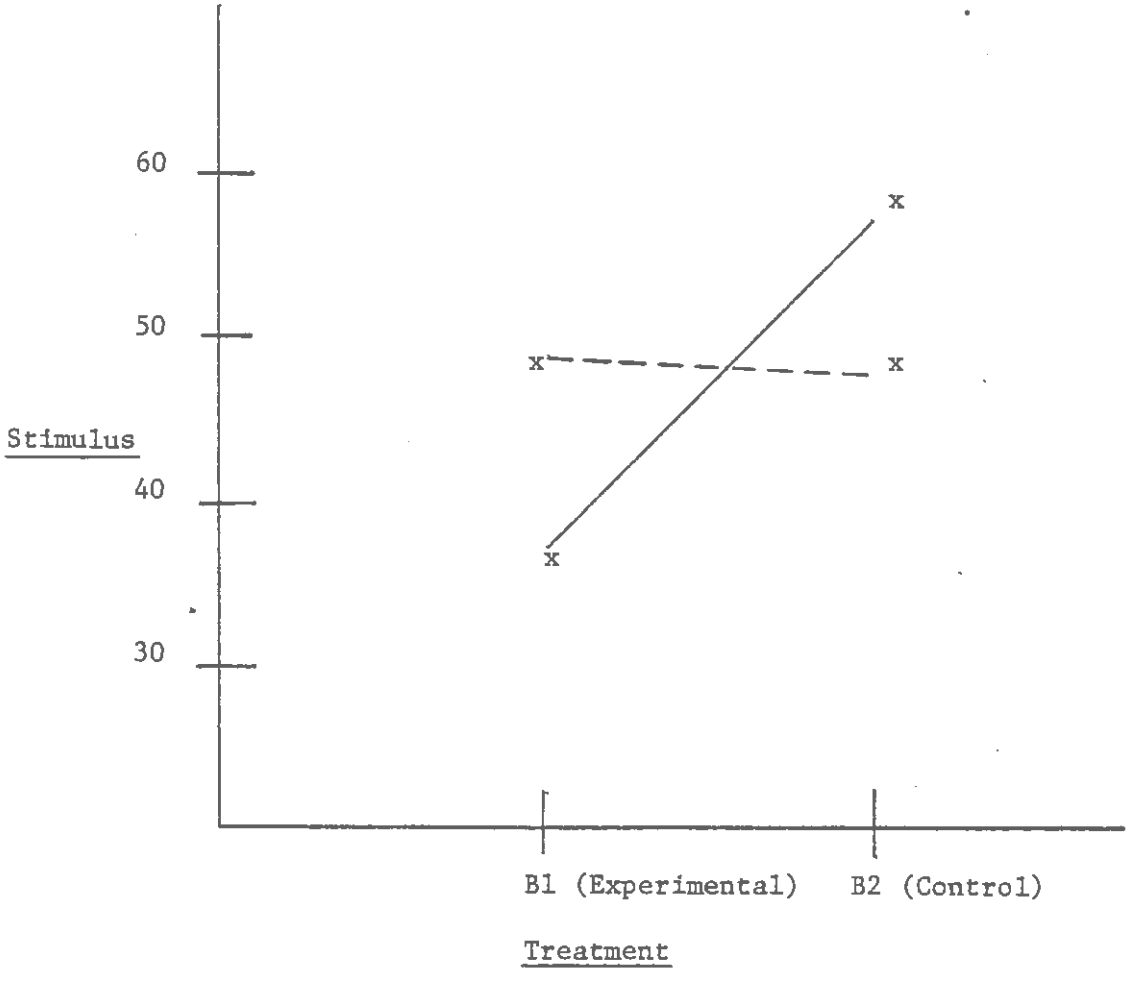

60
50
Stimulus
40
30
x
x
x
x
B1 (Experimental)
B2 (Control)
Treatment
x——x Stimulus 1 (C1)
x--------x Stimulus 2 (C2)

Figure 5

Insert Figure 6 about here

Insert Table 4 about here

A test of B (treatment) at C_1 (stimulus 1) (see Appendix G) indicated that control subjects responded significantly more often than experimental subjects to the lever which produced S_1, $F(1,84) = 55.01$, $p<.001$. No differences were found for levels of B (treatment) at C_2 (stimulus 2)

A test of C (stimulus) at B_1 (experimental) (see Appendix H) indicated that experimental subjects responded more to S_2 than to S_1, $F(1,126) = 28.15$, $p<.001$. In contrast, a test of C (stimulus) at B_2 (control) indicated that control subjects responded significantly more often to obtain S_1 and S_2, $F(1,126) = 11.81$, $p<.001$.

A priori simple, simple main effects tests (see Appendix I) together with appropriate follow-ups were performed on C (stimulus) at A_1B_1 (6 sec - 5 sec x experimental), C (stimulus) at A_2B_1 (14 sec - 13 sec x experimental), and C (stimulus) at A_3B_1 (14 sec - 5 sec x experimental) in order to test predictions outlined in the introduction. The required ABC (configuration x treatment x stimulus) summary tables are presented in Table 5.

Insert Table 5 about here

Figure Caption

Figure 6. Graph of BC (treatment X stimulus) interaction at levels of C (stimulus) across all subjects for Segments 1, 2, 3, and 4 of Day 1 of testing.

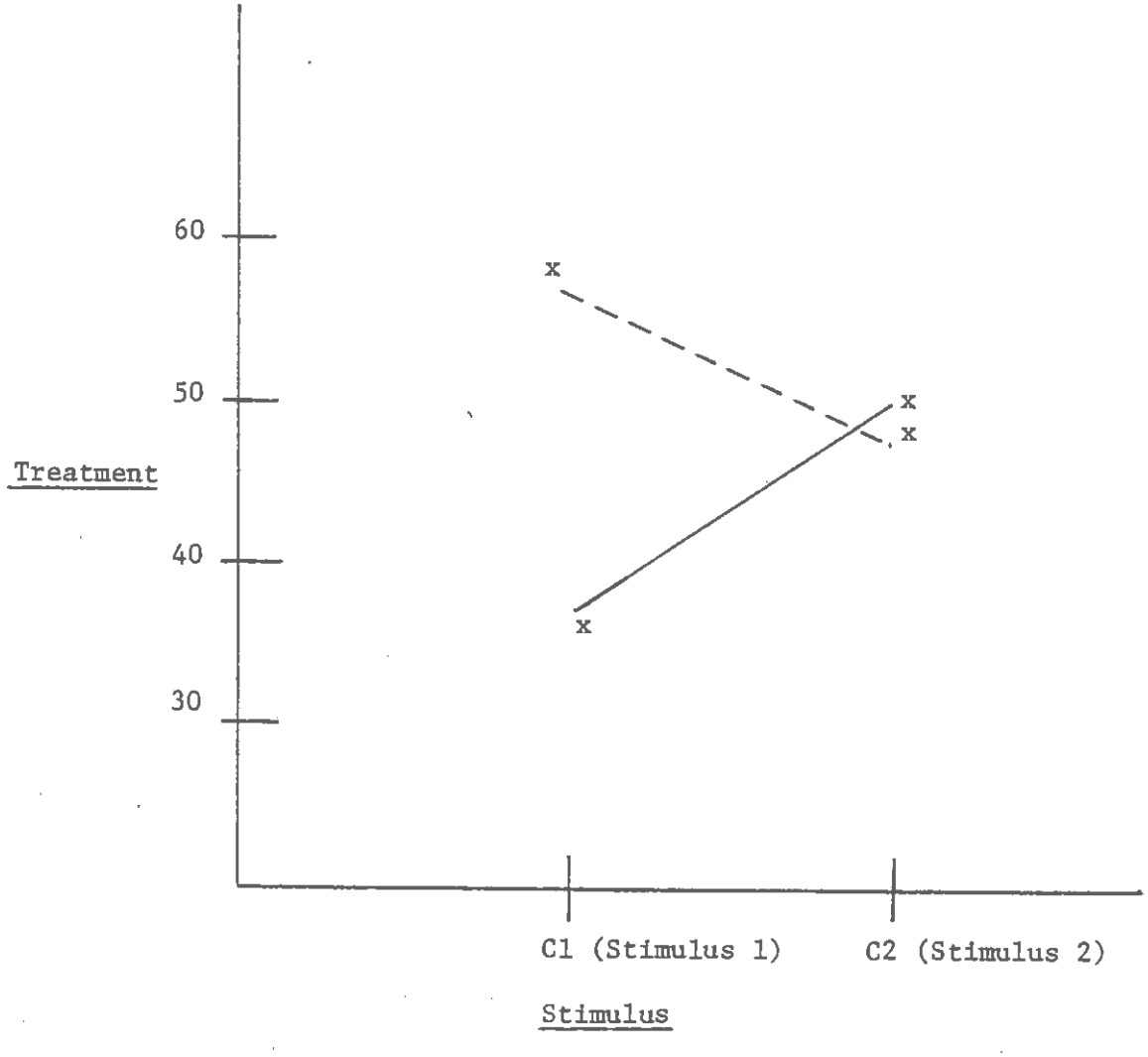

60
50
40
30
Treatment
C1 (Stimulus 1)
C2 (Stimulus 2)
Stimulus
x——x Experimental Ss (B1)
x- - - - - - - - -x Control Ss (B2)

Figure 6

TABLE 4

BC Summary Table:
Interaction of Treatment with Stimulus:
Day 1; Segments 1-4 of Log Transformed Scale

	C1 (Stimulus 1)	C2 (Stimulus)	Total
B1 (Experimental)	36.20634	49.69326	85.899
B2 (Control)	56.97976	48.25560	105.236
Total	93.186	97.949	191.135

TABLE 5

AB Summary Table
Interaction of Configuration with Treatment:
Day 1; Segments 1-4

	B1 (experimental)	B2 (control)	Total
A1 (6 sec-5 sec)	29.7704	26.8441	56.6145
A2 (14 sec-13 sec)	29.8051	38.6789	68.4840
A3 (14 sec-5 sec)	29.8569	39.7124	69.5693
Total	89.4324	105.2354	194.6678

ABC Summary Table
Interaction of Configuration with Treatment With
Stimulus: Day 1; Segments 1-4

	C1(Stimulus 1)	C2(Stimulus 2)	Total
A1B1(6 sec-5 sec x experiemntal)	13.9372	15.8332	29.7704
A1B2(6 sec-5 sec x control)	13.5322	13.3119	26.8441
A2B1(14 sec-13 sec x experimental)	11.6504	18.1547	29.8051
A2B2(14 sec-13 sec x control)	21.5750	17.1039	38.6789
A3B1(14 sec-5 sec x experimental)	14.1512	15.7057	29.8569
A3B2(14 sec-5 sec x control)	21.8726	17.8398	39.7124
Total	96.7186	93.9492	190.6678

No significant differences were found between levels of C at A_1B_1, or between levels of C at A_3B_1. However, at A_2B_1, experimental subjects responded more to obtain S_2 than to obtain S_1, $F(1,126) = 19.64$, $p<.001$.

As a follow-up to the identification of this significant effect, a test of C (stimulus) at A_2B_2 (14 sec - 13 sec x control) was performed. Results indicated that control subjects responded more to receive S_1 than S_2, $F(1,126) = 9.28$, $p<.005$. Further, a simple main effects test of B (treatment) at A_2 (14 sec - 13 sec) (see Appendix I) indicated that control subjects responded more during the first four 5-minute segments of testing than did experimental subjects, $F(1,42) = 5.01$, $p<.05$.

In order to statistically examine the possibility of a preference for one stimulus modality over the other, a dependent t-test was performed on overall responses to the tone versus the flashing light. No significant differences were found. However a dependent t-test of a position preference for the right versus left lever, indicated a right position preference, $t(47) = 2.02$, $p<.05$, underlining the importance of the experimental counterbalancing of this factor.

DISCUSSION

Results of the 4-way ANOVA with repeated measures across days of testing indicate that the testing procedure provided an opportunity for responding well beyond that necessitated by the training procedure. As indicated by a significant main effect across days of testing, responding was concentrated in the first 30-minute testing session (Day 1) with negligible responding occurring during testing on Days 2 and 3.

An examination of means and standard deviations across consecutive 5-minute testing periods on Day 1 indicates that extinction had occurred in some cells for the most part by the end of the fourth 5-minute session as indicated by means and standard deviations of 0 for cells in Segments 5 and 6. An a posteriori analysis would therefore indicate that, given these experimental training conditions, the more appropriate length of testing would approximate 20 minutes. This is not surprising given the use of the relatively conservative "new learning" paradigm which has shown in prior studies that, as new learning occurs, the S^r effect is simultaneously extinguishing.

Given the conclusion that extinction was complete in some cells at the end of the first 20 minutes of testing on Day 1, only Segments 1 through 4 were included in the second 4-way ANOVA. Results indicate that responding across all subjects was greatest in Segments 1 and 2, thereafter diminishing across Segments 3 and 4.

Of the three a-priori predictions regarding the establishment of S^r effects, none were confirmed. A follow-up analysis of the significant BC (treatment x stimulus) interaction and of the ABC (configuration x treatment x stimulus) interaction as dictated by the above-mentioned predictions, yielded largely equivocal results. Control subjects responded more to the first stimulus in the stimulus pair than did experimental subjects. It is possible that a pre-training preference for S_1 existed, as indicated by control subjects. Such a preference is likely to exist as a result of the functioning of a novel stimulus in the environment to which orienting responses would be directed (Sutherland, 1961). Such a preference for S1 would necessarily neutralize, to some extent, the establishment of what is likely to be at best a weak preference for S2 on the basis of contiguity with SR. Such an interference effect might also explain the lower levels of responding for experimental subjects as compared to controls, i.e., given an initial preference for the least contiguous stimulus, response suppression could occur in the process of establishing an alternate preference, i.e., as the orienting response is being weakened, the subject is learning an alternate preference. The extinguishing of the orienting response together with the pre-asymptotic learning of the new preference would account for lower overall responding. While it is possible to draw these explanatory inferences from the results, the position is at best speculative.

The only identifiable preference for S2 was indicated by experimental subjects receiving the 14 sec. S1/13 sec. S2 (A2) pairing

during training. Of the three S1S2 pairs, this pair is considered to be the least likely to develop an Sr effect for S2 since S2 in this pair has the least optimal contiguity interval with the primary reinforcer. Neither can an information model offer an adequate explanation for this result in view of the absence of an effect among subjects receiving either of the other two stimulus pairs.

If we assume that contiguity of S^r and SR is sufficient for a conditioned reinforcement effect, it would appear that the procedure employed, while well controlled, was not sufficiently sensitive methodologically for either the reliable establishment of or measurement of an Sr effect. In light of the fact that the present study was designed to incorporate aspects of studies by both Bersh (1951) and Egger and Miller (1963), both of which reported positive Sr effects, some discussion of differences between these studies and the present study is warranted.

The present study differed from Bersh's study (1) in that Bersh used a 23 1/2 hour food deprivation schedule rather than water deprivation and (2) in that Bersh measured baseline operant levels, and equated subjects accordingly during a pretraining procedure. Similar to the present study, Bersh employed a non-response contingent pairing procedure during training (though Bersh used food pellets and their associated sound cues, a 10-pellet magazine training period, and 160 pairings). While Bersh's design did find between group effects for the ISI variable, no controls were employed nor was any analysis performed to determine the extent to which test results

indicated an increase over baseline operant levels. It is important to note that the range of pretraining means used to equate subjects across experimental groups was limited to 34.8 to 35.3. Median responses across groups for the first test session following training, where responding was greatest, ranged from 27.5 to 41.0. It is conceivable therefore that a pre-post comparison of responses in Bersh's study would have indicated no learning effect.

While it is possible that the failure to replicate is the result of using water rather than food deprivation, the foregoing criticisms, regarding the lack of controls and the possible equivalence of pre and post training responding, together with the failure of the present study to yield an effect under similar, but somewhat better controlled training procedures, render Bersh's results somewhat questionable.

Egger and Miller's (1963) study, on the other hand, employed a somewhat more robust training procedure than that of the present study. In contrast to the conservative new learning procedure employed in the present design, Egger and Miller employed a relearning procedure. Subjects were first pretrained over a period of 6 25-minute sessions to lever press for the SR (food pellets) on an FR 4 schedule. Training was similar to that employed by the present study. However, testing began with subjects lever pressing on an FR3 schedule for thirty presentations of the SR alone. Following the presentation of the thirtieth pellet, a 10-minute extinction period ensued after which one of the previously neutral stimuli was delivered contingent upon

lever pressing. In contrast to the preference test employed in the present study, differential responding to S1 and S2 was assessed on the basis of responding for each stimulus on a single lever during consecutive test sessions, counterbalanced for order of S1 and S2 across subjects.

While Egger and Miller's results are questionable on other grounds (as indicated in the introduction), they were able to demonstrate reliable differential effects. It is possible that the procedure employed herein, while substantially less confounded than that used by Egger and Miller, was simply too conservative to yield measurable results.

In considering various aspects of the present study independently, one possible reason for the failure to find a reliable effect stems from the inability to measure the number of pairings actually received in contrast to the number presented. While animals were observed to be dipper trained and actively seeking the sucrose solution at the food cup, such observations were performed intermittently by the experimenter and were not systematically measured.

Along this line, some authors (Silverstein & Lipsitt, 1974; Keehn, 1962; Doerries, Silverstein, & Smith, in press) have suggested that pairing must be contingent upon some instrumental response during training in order for an Sr effect to be established. It is possible, however, that it is not the operant itself which is critical but rather the fact that the operant maximizes the probability that the SrSR pair will be received by the subject. The work of Stein

(1958) and Crowder et al. (1972) would certainly support this alternate interpretation of the effect of the operant in Sr training. It is also possible that these authors (Silverstein & Lipsitt, 1974; Keehn, 1962; Doerries, Silverstein, & Smith, in press) are correct in postulating the necessity of response contingent training for the establishment Sr effects. If this is, in fact, a requirement, the results of this study can be attributed merely to the effect of opposite stimulus novelty.

An additional possibility is that Sr effects were established but were relatively weak and therefore below the threshold necessary for yielding a significant effect. Doerries et al. (in press), for example, found that by varying testing to incorporate both a distributed (versus massed) procedure and a delay over time, a remarkably durable Sr effect was identifiable, with subjects required to perform an operant during training. This durability was attributed in large part to a spontaneous recovery effect.

Finally, it is possible that a more appropriate test of Sr effects involves the use of the contiguous S1S2 pair. Some authors (Thomas, Berman, Serednesky, & Lyons, 1968; Borgealt, Donahoe, & Weinstein, 1972) have evidence for the effectiveness of the compound in contrast to either S1 or S2 individually. It is suggested that it is the compound which is the most contiguous with the SR and that the preference for S1 over S2 as found by Egger and Miller is more parsimoniously explained by the phenomenon of stimulus generalization decrement; that is, while S2 only occurs in compound with S1, S1

occurs alone and therefore is less subject to stimulus generalization decrement from training to testing.

Additional research is suggested (1) which insures that the SrSR pair is received upon presentation non-contingently (as in the study by Crowder et al., 1972) and (2) which measures the relative effectiveness of the stimulus compound as well as the individual stimuli. The careful investigation of these variables could offer some clarification of the largely equivocal results obtained in this study.

REFERENCES

Autor, S. H. The strength of conditioned reinforcers as a function of frequency and probability of reinforcement. In D. P. Hendry (Ed.), Conditioned Reinforcement. Homewood, Ill.: Dorsey Press, 1969, 127-162.

Bersh, P. J. The influence of two variables upon the establishment of a secondary reinforcer for operant responses. Journal of Experimental Psychology, 1951, 41, 62-73.

Bilbrey, J. & Winokur, S. Conditioned reinforcement: Effects of temporal contingency and percentage of pairing. Journal of General Psychology, 1975, 93, 247-260.

Bolles, R. C. Theory of Motivation. New York: Harper & Row, 1967.

Borgealt, A. J., Donahoe, J. W., & Weinstein, A. Effects of delayed and trace components of a compound CS on conditioned suppression and heart rate. Psychonomic Science, 1972, 26, 13-15.

Bower, G., McLean, J., & Meacham, J. Value of knowing when reinforcement is due. Journal of Comparative and Physiological Psychology, 1966, 62, 184-192.

Box, G. E. P. Non-normality and tests of variances. Biometrika, 1953, 40, 318-335.

Bugelski, R. Extinction with and without sub-goal reinforcement. Journal of Comparative Psychology, 1938, 26, 121-133.

Crowder, W. F., Smith, S. G., Davis, W. M., Noel, J. T., & Cousseus, W. R. Effect of morphine dose size on the conditioned reinforcer

potency of stimuli paired with morphine. Psychological Record, 1972, 22, 441-448.

D'Amato, M. R. Secondary reinforcement and magnitude of primary reinforcement. Journal of Comparative and Physiological Psychology, 1955, 48, 378-380.

Dinsmoor, J. A. A quantitative comparison of the discriminative and reinforcing functions of a stimulus. Journal of Experimental Psychology, 1950, 40, 458-472.

Doerries, L. E., Silverstein, A., & Smith, N. F. Acquisition and retention of conditioned reinforcement as a function of variability in training setting and distribution of testing, in press.

Egger, M. D. & 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, C. B. Sustained behavior under delayed reinforcement. Journal of Experimental Psychology, 1953, 45, 218-224.

Gilbert, T. F. & Sturdivant, E. R. The effect of a food-associated stimulus on operant-level locomotor behavior. Journal of Comparative and Physiological Psychology, 1958, 51, 255-257.

Greene, J. E. Magnitude of reward and acquisition of a black-white discrimination habit. Journal of Experimental Psychology, 1953, 46, 113-119.

Guttman, N. Operant conditioning, extinction, and periodic reinforcement in relation to concentration of sucrose used as reinforcing

agent. Journal of Experimental Psychology, 1953, 46, 213-224.

Hendry, D. P. (Ed.) Conditioned Reinforcement. Homewood, Ill.: Dorsey Press, 1969.

Hyde, T. S. The effect of Pavlovian stimuli on the acquisition of a new response. Learning and Motivation, 1976, 7, 223-239.

Keehn, J. D. The effect of post-stimulus conditions on the secondary reinforcing power of a stimulus. Journal of Comparative and Physiological Psychology, 1962, 55, 22-26.

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

Keller, F. S. & Schoenfeld, W. N. Principles of Psychology. New York: Appleton-Century-Crofts, 1950.

Kling, J. W. & Schrier, A. M. Positive reinforcement. In Kling, J. W. & Riggs, L. A. (Eds.) Experimental Psychology. 3rd ed. New York: Holt, Rinehart, & Winston, 1972, 615-702.

Longstreth, L. E. A cognitive interpretation of secondary reinforcement. Nebraska Symposium of Motivation, 1971, 33-80.

Pliskoff, S. S., Hawkins, T. D., & Wright, J. E. Some observations of the discriminative stimulus hypothesis and rewarding electrical stimulation of the brain. Psychological Record, 1964, 14, 179-184.

Ratner, S. C. Effect of extinction of dipper approaching on subsequent extinction of bar-pressing and dipper-approaching. Journal of Comparative and Physiological Psychology, 1956, 49, 576-581.

Rescorla, R. A. Pavlovian conditioning and its proper control procedures. Psychological Review, 1967, 74, 71-80.

Saltzman, I. J. Maze learning in the absence of primary reinforcement: A study of secondary reinforcement. Journal of Comparative and Physiological Psychology, 1949, 12, 161-173.

Shoenfeld, W. N., Antonitis, J. J., & Bersh, P. J. A preliminary study of training conditions necessary for secondary reinforcement. Journal of Experimental Psychology, 1950, 40, 40-45.

Silverstein, A. & Lipsitt, L. P. The role of instrumental responding and contiguity of stimuli in the development of infant secondary reinforcement. Journal of Experimental Child Psychology, 1974, 17, 322-221.

Skinner, B. F. The Behavior of Organisms. New York: Appleton-Century-Crofts, 1938.

Stein, L. Secondary reinforcement established with subcortical stimulation. Science, 1958, 127, 466-467.

Sutherland, N. S. Visual discrimination of horizontal and vertical rectangles by rats on a new discrimination training apparatus. Quarterly Journal of Experimental Psychology, 1961, 13, 117-121.

Thomas, D. R., Berman, D. L., Serednesky, G. E., & Lyons, J. Information value and stimulus configuring as factors in conditioned reinforcement. Journal of Experimental Psychology, 1968, 76, 181-189.

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

Wolfe, J. B. Effectiveness of token rewards for chimpanzees. Comparative Psychology Monographs, 1936, 12, 1-72.

Wyckoff, L. B. The role of observing responses in discrimination learning. In D. P. Hendry (Ed.) Conditioned Reinforcement. Homewood, Ill.: Dorsey Press, 1969, 237-260.

APPENDIX A

Means and Standard Deviations for Number of Lever Presses During Testing

Part I. D_1 (Day 1; 30 Minute Session)

A_1 (S_1, 6 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\overline{X}$	14.37	12.62
	SD	11.41	8.24
C_2 (Stimulus 2)	$\overline{X}$	20.87	39.62
	SD	22.54	87.57

A_2 (S_1, 14 seconds; S_2, 13 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\overline{X}$	21.75	67.87
	SD	31.83	125.88
C_2 (Stimulus 2)	$\overline{X}$	22.87	26.25
	SD	23.54	19.28

A_3 (S_1, 14 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\overline{X}$	15.62	24.37
	SD	8.50	8.26
C_2 (Stimulus 2)	$\overline{X}$	20.00	18.50
	SD	21.51	13.68

APPENDIX A

Means and Standard Deviations for Number of Lever Presses During Testing

Part II. D_2 (Day 2; 30 Minute Session)

A_1 (S_1, 6 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	12.37	17.00
	SD	10.74	24.43
C_2 (Stimulus 2)	$\bar{X}$	15.50	7.25
	SD	26.50	6.86

A_2 (S_1, 14 seconds; S_2, 13 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	9.37	20.37
	SD	13.90	32.70
C_2 (Stimulus 2)	$\bar{X}$	6.62	20.25
	SD	6.32	31.17

A_3, (S_1, 14 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	13.87	17.87
	SD	14.33	23.87
C_2 (Stimulus 2)	$\bar{X}$	12.87	18.37
	SD	11.76	23.20

APPENDIX A

Means and Standard Deviations for Number of Lever Presses During Testing

Part III. D_3 (Day 3; 30 minute session)

A_1 (S_1, 6 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	7.75	7.62
	SD	10.85	9.82
C_2 (Stimulus 2)	$\bar{X}$	6.75	5.37
	SD	8.94	5.20

A_2 (S_1, 14 seconds; S_2, 13 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	8.25	19.37
	SD	11.33	30.32
C_2 (Stimulus 2)	$\bar{X}$	8.00	14.37
	SD	6.32	14.27

A_3 (S_1, 14 seconds; S_2, 5 seconds)

		B_1 (Experimental)	B_2 (Control)
C_1 (Stimulus 1)	$\bar{X}$	12.00	16.37
	SD	19.36	22.28
C_2 (Stimulus 2)	$\bar{X}$	7.37	8.37
	SD	5.04	14.92

APPENDIX B

Means and Standard Deviations of Log Transformed Scale For Number of Lever Presses During Testing

Part I. D1 (Day 1; 30 minute sessions)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	1.04	1.00
	SD	0.39	0.45
C2 (Stimulus 1)	$\bar{X}$	1.12	1.10
	SD	0.48	0.58

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.90	1.35
	SD	0.72	0.67
C2 (Stimulus 2)	$\bar{X}$	1.15	1.35
	SD	0.55	0.26

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	1.16	1.38
	SD	0.23	0.13
C2 (Stimulus 2)	$\bar{X}$	1.13	1.21
	SD	0.45	0.26

APPENDIX B

Means and Standard Deviations of Log Transformed Scale For Number of Lever Presses During Testing

Part II. D2 (Day 2; 30 minute sessions)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.96	0.84
	SD	0.42	0.67
C2 (Stimulus 2)	$\overline{X}$	0.80	0.72
	SD	0.65	0.48

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.79	1.02
	SD	0.43	0.51
C2 (Stimulus 2)	$\overline{X}$	0.72	1.08
	SD	0.42	0.43

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.98	1.03
	SD	0.45	0.47
C2 (Stimulus 2)	$\overline{X}$	0.98	1.00
	SD	0.40	0.58

APPENDIX B

Means and Standard Deviations of Log Transformed Scale For Number of Lever Presses During Testing

Part III. D3 (Day 3; 30 minute sessions)

A1 (S1, 6 seconds; S2; 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.63	0.76
	SD	0.58	0.37
C2 (Stimulus 2)	$\overline{X}$	0.61	0.68
	SD	0.54	0.34

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.73	1.01
	SD	0.47	0.48
C2 (Stimulus 2)	$\overline{X}$	0.83	0.94
	SD	0.37	0.52

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.74	0.92
	SD	0.59	0.55
C2 (Stimulus 2)	$\overline{X}$	0.83	0.70
	SD	0.30	0.43

APPENDIX C

Newman-Keuls Test of Days 1, 2, and 3 Across all Subjects

	D3 Day 3 0.76	D2 Day 2 0.91	D1 Day 1 1.16
D3		0.14	0.39*
D2			0.24**

* $p<.01$; df (3,42)

** $p<.01$; df (2.42)

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part I. D1 (Segment 1; 5 minutes)

S1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	4.50	4.25
	SD	5.70	2.81
C2 (Stimulus 2)	$\bar{X}$	7.25	2.12
	SD	9.43	2.47

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	11.37	5.12
	SD	18.67	4.79
C2 (Stimulus 2)	$\bar{X}$	8.37	6.50
	SD	8.89	5.31

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	8.00	9.87
	SD	6.61	4.58
C2 (Stimulus 2)	$\bar{X}$	8.00	6.00
	SD	9.88	3.77

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part II. D2 (Segment 2; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	3.25	5.62
	SD	2.76	4.86
C2 (Stimulus 2)	$\bar{X}$	4.37	5.87
	SD	5.23	8.96

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	5.87	26.87
	SD	10.02	56.16
C2 (Stimulus 2)	$\bar{X}$	6.12	3.62
	SD	8.21	2.77

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	2.37	4.12
	SD	2.50	2.90
C2 (Stimulus 2)	$\bar{X}$	3.62	3.75
	SD	4.24	2.71

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part III. D3 (Segment 3; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.87	1.25
	SD	1.45	1.28
C2 (Stimulus 2)	$\bar{X}$	4.75	10.37
	SD	8.15	22.23

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.50	24.37
	SD	1.41	61.70
C2 (Stimulus 2)	$\bar{X}$	2.75	5.12
	SD	3.24	11.72

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	2.00	6.25
	SD	3.16	4.52
C2 (Stimulus 2)	$\bar{X}$	1.62	3.50
	SD	1.68	5.39

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part IV. D4 (Segment 4; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	5.25	0.37
	SD	7.94	0.74
C2 (Stimulus 2)	$\bar{X}$	3.62	0.50
	SD	8.29	0.75

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	1.12	7.37
	SD	2.79	16.21
C2 (Stimulus 2)	$\bar{X}$	1.87	5.75
	SD	1.45	12.03

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	1.37	1.50
	SD	1.68	1.51
C2 (Stimulus 2)	$\bar{X}$	5.25	4.00
	SD	12.45	6.96

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part V. D5 (Segment 5; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.50	0.37
	SD	0.92	0.51
C2 (Stimulus 2)	$\overline{X}$	0.00	18.50
	SD	0.00	49.92

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	2.12	3.00
	SD	4.51	6.16
C2 (Stimulus 2)	$\overline{X}$	2.75	3.00
	SD	3.99	3.96

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	1.25	1.37
	SD	1.38	2.13
C2 (Stimulus 2)	$\overline{X}$	1.12	0.37
	SD	1.35	0.74

APPENDIX D

Means and Standard Deviations for Number of Lever Presses During Day 1 of Testing

Part VI. D6 (Segment 6; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.00	0.75
	SD	0.00	1.75
C2 (Stimulus 2)	$\bar{X}$	0.87	2.25
	SD	2.47	5.25

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.75	1.25
	SD	1.48	1.83
C2 (Stimulus 2)	$\bar{X}$	1.00	2.25
	SD	1.77	3.41

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.75	1.25
	SD	1.16	1.75
C2 (Stimulus 2)	$\bar{X}$	0.37	0.87
	SD	0.74	1.12

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part I. D1 (Segment 1; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.54	0.64
	SD	0.44	0.31
C2 (Stimulus 2)	$\bar{X}$	0.62	0.35
	SD	0.55	0.38

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.71	0.65
	SD	0.61	0.38
C2 (Stimulus 2)	$\bar{X}$	0.79	0.75
	SD	0.44	0.38

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.77	0.98
	SD	0.50	0.25
C2 (Stimulus 2)	$\bar{X}$	0.72	0.78
	SD	0.50	0.23

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part II. D2 (Segment 2; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.51	0.66
	SD	0.36	0.44
C2 (Stimulus 2)	$\bar{X}$	0.57	0.59
	SD	0.39	0.46

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.49	0.90
	SD	0.56	0.65
C2 (Stimulus 2)	$\bar{X}$	0.65	0.57
	SD	0.43	0.33

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.42	0.65
	SD	0.33	0.24
C2 (Stimulus 2)	$\bar{X}$	0.50	0.56
	SD	0.40	0.37

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part III. D3 (Segment 3; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.18	0.28
	SD	0.27	0.26
C2 (Stimulus 2)	$\overline{X}$	0.45	0.58
	SD	0.53	0.62

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.87	0.68
	SD	0.24	0.70
C2 (Stimulus 2)	$\overline{X}$	0.42	0.38
	SD	0.39	0.53

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.30	0.77
	SD	0.39	0.29
C2 (Stimulus 2)	$\overline{X}$	0.50	0.56
	SD	0.27	0.44

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part IV. D4 (Segment 4; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.49	0.09
	SD	0.55	0.18
C2 (Stimulus 2)	$\bar{X}$	0.32	0.13
	SD	0.48	0.19

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.15	0.44
	SD	0.33	0.61
C2 (Stimulus 2)	$\bar{X}$	0.39	0.42
	SD	0.27	0.56

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\bar{X}$	0.27	0.31
	SD	0.31	0.28
C2 (Stimulus 2)	$\bar{X}$	0.39	0.43
	SD	0.51	0.46

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part V. D5 (Segment 5; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.11	0.11
	SD	0.22	0.15
C2 (Stimulus 2)	$\overline{X}$	0.0	0.41
	SD	0.0	0.75

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.25	0.26
	SD	0.42	0.50
C2 (Stimulus 2)	$\overline{X}$	0.36	0.45
	SD	0.44	0.37

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.26	0.25
	SD	0.29	0.32
C2 (Stimulus 2)	$\overline{X}$	0.24	0.09
	SD	0.28	0.18

APPENDIX E

Means and Standard Deviations of Log Transformed Scale for Number of Lever Presses During Day 1 of Testing

Part VI. D6 (Segment 6; 5 minutes)

A1 (S1, 6 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.0	0.13
	SD	0.0	0.28
C2 (Stimulus 2)	$\overline{X}$	0.11	0.22
	SD	0.31	0.44

A2 (S1, 14 seconds; S2, 13 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.14	0.23
	SD	0.27	0.33
C2 (Stimulus 2)	$\overline{X}$	0.19	0.30
	SD	0.29	0.43

A3 (S1, 14 seconds; S2, 5 seconds)

		B1 (Experimental)	B2 (Control)
C1 (Stimulus 1)	$\overline{X}$	0.17	0.25
	SD	0.25	0.30
C2 (Stimulus 2)	$\overline{X}$	0.09	0.21
	SD	0.18	0.24

APPENDIX F

Newman-Keuls Test of Segments 1, 2, 3 and 4
Across all Subjects

	D4 Segment 4 0.32	D3 Segment 3 0.41	D2 Segment 2 0.59	D1 Segment 1 0.69
D4		0.87	0.26**	0.37***
D3			0.18*	0.28**
D2				0.10

* $p<.05$; df (2,126)

** $p<.01$; df (3,126)

*** $p<.01$; df (4,126)

APPENDIX G

Simple Main Effects Tests of B (treatment) at C (stimulus) Across all Subjects for Segments 1, 2, 3 and 4 of Day 1 of Testing

Source	SS	df	MS	F
B at C1 (Stimulus 1)	8.99	1	8.99	55.01*
B at C2 (Stimulus 2)	0.04	1	0.04	0.25
Error	13.73	84	0.16	

* $p<.001$

APPENDIX H

Simple Main Effects Tests of C (stimulus) at B (treatment) Across all Subjects for Segments 1, 2, 3 and 4 of Day 1 of Testing

Source	SS	df	MS	F
C at B1 (Experimental)	3.79	1	3.79	28.15*
C at B2 (Control)	1.59	1	1.59	11.81*
Error	16.96	126	0.13	

* $p < .001$

APPENDIX I

Simple, Simple Main Effects Tests of C (stimulus) at AB (configuration x treatment) for Segments 1, 2, 3 and 4 of Day 1 of Testing

Source	SS	df	MS	F
C at A1B1 (6 sec-5 sec x exper)	0.22	1	0.22	1.67
C at A2B1 (14 sec-13 sec x exper)	0.64	1	2.65	19.64**
C at A2B2 (14 sec-13 sec x cont)	1.24	1	1.24	9.28*
C at A3B1 (14 sec-5 sec x exper)	0.15	1	0.15	1.12
Error	16.96	126	0.13	

* $p<.005$

** $p<.001$

APPENDIX J

Simple Main Effects Tests of B (treatment) at A2 (14 sec-13 sec) for Segments 1, 2, 3 and 4 of Day 1 of Testing

Source	SS	df	MS	F
B at A2 (14 sec-13 sec)	2.46	1	2.46	5.00*
Error	20.63	42	0.49	

*p<.05