BIAS IN AVOIDANCE-YOKED EYELID CONDITIONING COMPARISONS

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By

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ABSTRACT

Yoked groups have often been used as controls against which to assess the effects of a contingency between a response and some event. For example, Moore and Gormezano (1961) used a yoked control group in an experiment designed to assess the effects of an avoidance contingency in human eyelid conditioning. For the avoidance subjects in their study, an eyelid closure during the CS-US interval precluded the delivery of the air puff US. Each avoidance subject was given a yoked partner who received the air puff, without regard to his responding, on those trials when his avoidance partner received it. In this way, the avoidance and yoked control groups were equated for number and pattern of USs, and differed only with respect to the instrumental contingency.

Moore and Gormezano's (1961) finding was that the avoidance group reached a higher asymptotic level of conditioned responding than the yoked group. However, Church (1964) has argued that the results of such instrumental-yoked comparisons are ambiguous since any effects due to the contingency are confounded with the effects of a bias in the design favoring the instrumental subject. The purpose of the present research was to evaluate Church's argument that bias arising from within-pair mismatching in effectiveness contributes to the avoidance-yoked difference obtained in eyelid conditioning.

Three rabbit eyelid conditioning experiments involving a total of 228 subjects are described. Pre-yoke matching (Experiment 1), multiple yoking (Experiment 2), and reciprocal yoking and self-yoking

(Experiment 3), procedures were implemented. The results of the between-subject, and within-subject, avoidance-yoked contrasts in these experiments support Church's (1964) conceptualization of a yoked subject as one that receives more, or fewer, shocks, and in a different pattern, that it would if delivery of shocks were contingent upon its own behavior. Hence, the major conclusion that is drawn from these experiments is that differences in acquisition performance between avoidance and yoked subjects in the rabbit eyelid conditioning preparation are the result of bias. The findings of this investigation suggest that the instrumental-yoked differences obtained in other research programs may also reflect bias in the yoked control design, and not the effects of the instrumental contingency *per se*.

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CHAPTER 1

INTRODUCTION

Yoked Control Design

Experiments designed to assess the effects of a contingency between a response and some event have traditionally included a control for the unconditioned effects of the event. A procedure that has often been used to provide such a control is to give each experimental subject a yoked partner that receives the same number and pattern of events. This appears to be an ideal procedure since it insures that the experimental and control groups differ only with respect to the instrumental contingency.

The yoking procedure was first used by Mowrer and Viek (1948) to assess the effects of an escape contingency on the amount of fear produced by shock in rats. In their study, the experimental subjects could, by leaping into the air, terminate a shock that followed food presentation. Each rat in this group had a yoked partner in the control group. No response by these yoked control subjects could terminate the shock; instead, each of these subjects received, trial for trial, the same duration of shock as that received by its experimental partner. The results indicated that the experimental subjects more frequently ate the food that preceded shock delivery than did the subjects in the control group. Mowrer and Viek concluded from these results that inescapable shock is more fear-inducing than escapable shock.

Although Mowrer and Viek had introduced an important procedural innovation, it was not widely used until the early '60s. Still, there were a few programs of research on instrumental contingency effects during the '50s that adopted the yoking procedure, and the first experiment in which yoking was used in each of these programs is described briefly below.

The earliest instance of a reappearance of the yoking procedure was in an experiment by Kling, Horowitz and Delhagen (1956). These investigators sought to determine whether chamber illumination could serve as a positive reinforcer for rats. For the experimental subjects in their study, touching a bar resulted in illumination of the chamber. Each control subject, placed in a separate chamber, received the same amount and pattern of illumination as its experimental partner. The results indicated that the experimental subjects touched the bar significantly more often than the yoked control subjects, and the authors concluded that the contingency between bar-touching and chamber illumination was effective in producing the response.

Sawrey, Conger and Turrell (1956) used the yoking procedure in an experiment designed to assess the effects of an approach-avoidance conflict on the development of ulcers in rats. Food and water were always available to the subjects in the experimental group, but during 47 of every 48 hr they had to cross an electric grid in order to reach them. Each subject in this group had a yoked partner in a control group that did not have access to food and water during these 47 hr and received shock whenever it was received by its experimental partner. The results indicated that the subjects in the experimental group developed more ulcers than those in the yoked group, and Sawrey _et al_. concluded that psychological conflict had contributed to ulcer formation.

Ferster and Skinner (1957, pp. 399-407), who coined the term "yoked", used the yoking procedure to obtain data on whether the high rates of responding that are characteristic of a variable ratio (VR) schedule are due to the high frequency of reinforcement generated by this schedule or to the differential reinforcement of groups of responses. Two pigeons were first trained to key-peck on a variable interval (VI) schedule and, by varying deprivation level, were matched for response rate. Then, one bird was switched to a VR schedule and the other to a yoked-VI schedule such that reinforcements were set up for the second bird whenever they were obtained by the first bird. After a few sessions, the response rate for the bird on the VR schedule increased to more than 2/sec while the response rate for its yoked partner stabilized at about 1/sec. These results were not replicated in a second pair of birds. In this case, the pigeon that was switched to the VR schedule failed to maintain responding.

Wyckoff, Sidowski and Chambliss (1958) introduced the yoking procedure in studies on secondary reinforcement. Rats in their second experiment were first trained to bar-press for water, and then to lick a water dipper when a buzzer was sounded. In a subsequent test phase, yoked pairs were formed, and buzzer presentations were made contingent upon bar-pressing for the experimental subject in each pair. The results of the test revealed no difference in rate of bar-pressing between the experimental subjects and their yoked control partners, and these results were taken as evidence that the buzzer had not acquired secondary reinforcing properties.

Yoked groups were also used by Logan (1960) in a series of studies on the effects of positively- and negatively-correlated reinforcement on alley-running in rats. In one of these studies (Experiment 57D, pp. 163 ff.), the experimental subjects were rewarded only if they reached the goal box no sooner than 5 sec after the start door opened. Yoked subjects received the reward on those trials when it was obtained by their respective experimental partners. The results showed that the experimental subjects ran more slowly than the yoked subjects, and Logan concluded that rats can learn to run slowly if they are reinforced for doing so.

Avoidance-Yoked Eyelid Conditioning Comparisons

Moore and Gormezano (1961) were the first to use the yoking procedure in the eyelid conditioning preparation. Their study was a particularly significant one in a series that had compared the efficacies of classical and avoidance human eyelid conditioning, since it provided, for the first time, a comparison in which the classical and avoidance groups were equated for number and pattern of unconditioned stimuli (USs). Earlier studies (Logan, 1951; Kimble, Mann & Dufort, 1955; Hansche, 1959) had found that subjects on a 100% classical contingency, in which the conditioned stimulus (CS) and the US are given to a subject on every trial regardless of his behavior, evidenced more conditioned responses (CRs) than subjects on an avoidance contingency, in which the US is omitted on those trials when the subject evidences a CR. However, these comparisons did not permit a conclusion regarding the relative effects of the contingencies *per se*, since the classical and avoidance groups differed in the number of USs that they received.

In Moore and Gormezano's (1961) yoking experiment, the CS was a 600 msec change in illumination and hue of a screen that faced the subject, the US was a 100 msec, 200 mm Hg, air puff directed to the subject's right eye, and the CS-US interval was 500 msec. For a subject in the avoidance group, an eyelid closure during the CS-US interval precluded the delivery of the air puff to himself and to his partner in the yoked group. A third group received 100% classical conditioning. Comparisons of acquisition performance in these groups indicated that: 1) consistent with earlier reports (Logan, 1951; Kimble, Mann & Dufort, 1955; Hansche, 1959), the group that received 100% classical conditioning evidenced more CRs than the avoidance group, and 2) the avoidance group reached a higher asymptotic CR level than the yoked group.

In a subsequent study, Gormezano, Moore and Deaux (1962) examined avoidance-yoked differences under three intensities of the US. Different sets of avoidance and yoked groups were conditioned with US intensities of 40, 80 and 160 mm Hg. Other parameters in this study were the same as those used in the previous study by Moore and Gormezano (1961). Acquisition curves showed that the avoidance-yoked separation was large in the high-intensity condition, intermediate in the middle-intensity condition, and small in the low-intensity condition.

In another parametric study, Gormezano, Fluentes and Erickson (1963; see Gormezano, 1965) used the nictitating membrane conditioning preparation in the rabbit to assess avoidance-yoked differences under three CS-US intervals. The CS was an 800 Hz tone, and the air puff US was set at 75 mm Hg. The results indicated that the avoidance-yoked difference was large at the shortest interval (500 msec), intermediate at the middle interval (1000 msec), and non-existent at the longest interval (1500 msec).

The relationship between CS-US interval and magnitude of avoidance-yoked differences was also investigated in a nictitating membrane conditioning experiment by Hupka, Massaro and Moore (1968). In their study, the CS was a 1200 Hz tone and the US was a 2 mA shock delivered through wound clips to the infraorbital region of the rabbit's eye. The results of acquisition performance revealed a significant avoidance-yoked difference in the 1000 msec condition but no avoidance-yoked difference in the 250 msec condition. In the latter condition, acquisition was very rapid for both avoidance and yoked groups.

The acquisition findings in this collection of eyelid conditioning studies, disregarding differences in procedure, may be summarized as follows: The avoidance group generally evidenced more CRs than the yoked group. The avoidance-yoked difference was largest with a CS-US interval of 500 msec and a US air puff intensity of 160 mm Hg (Gormezano, Moore & Deaux, 1962). The avoidance-yoked difference was smaller when the CS-US interval was shorter (Hupka, Massaro & Moore, 1968) and longer (Gormezano, Fluentes & Erickson, 1963) than 500 msec. Similarly, the avoidance-yoked difference was smaller when the US intensity was stronger (Moore & Gormezano, 1961) and weaker (Gormezano, Moore & Deaux, 1962) than 160 mm Hg. In short, the findings suggest that the optimal parameters for obtaining a reliable avoidance-yoked difference are those that produce fast, but not the fastest (Hupka, Massaro & Moore, 1968), acquisition.

Bias in Instrumental-Yoked Comparisons

Church (1964) argued that yoked groups were inappropriate as controls against which to assess instrumental contingency effects. His thesis was that, in all instrumental-yoked comparisons, any effects due to the contingency are confounded with the effects of a bias in the design favoring the instrumental subject. In developing his argument, Church focussed on Moore and Gormezano's (1961) study of the effects of an avoidance contingency in human eyelid conditioning. His line of argument was to begin with the assumption that the null hypothesis is true, i.e., that the avoidance contingency has no effect on the production of CRs, and then to show that an avoidance-yoked difference in number of CRs would occur even if the null hypothesis were true.

Church's argument proceeded in the following way: The assumption was made that events are differentially effective across organisms of a species, such that air puffs would produce faster eyelid conditioning in some subjects than in others. Simplifying his exposition, Church considered two types of subjects - "effective" and "ineffective". Effective subjects referred to those for whom conditioning proceeded rapidly, while ineffective subjects referred to those for whom conditioning proceeded slowly. With two types of subjects, random pairing would yield four different, possible experimental-yoked combinations - effective-effective, ineffective-ineffective, effective-ineffective and ineffective-effective. Church then examined the expected results of conditioning in each of these cases.

In the effective-effective case, since both the experimental and the yoked subject are effective, the same small number of air puffs would be expected to produce equal numbers of CRs in both members of the pair. Similarly, in the case of an ineffective-ineffective match, the same large number of air puffs would be expected to produce equal numbers of CRs in both members of the pair. Thus, the cases in which subjects are matched would not result in any experimental-yoked difference in conditioned responding.

In the case where an effective experimental subject is paired with an ineffective yoked subject, the experimental subject would evidence many CRs, thereby precluding the air puff on a large number of trials. Hence, his partner would receive few air puffs, and since he is an ineffective subject, would show very few CRs. Church described the other mismatch case as follows:

> "If, on the other hand, an experimental _S_ that is not affected by the event is matched with a control _S_ that is affected, neither will make many responses. The experimental _S_ will rarely make a response (by assumption) and the control _S_ will not make many responses either because it only occasionally receives an event (p. 124)."

Thus, the results of the second mismatch would not cancel out the results of the first mismatch, so that, on the whole, the experimental subjects would evidence more CRs than the yoked control subjects.

Therefore, Church concluded from his analysis that Moore and Gormezano's (1961) finding that the avoidance group evidenced more CRs than the yoked group may have reflected this bias arising from within-pair mismatching in effectiveness, and not the effects of the avoidance contingency.

However, several writers (Grings & Carlin, 1966; Black, 1967; Katkin, Murray & Lachman, 1969) have noted that, in his description of the case where an ineffective experimental subject is paired with an effective control subject, Church made a mistake. Far from only "occasionally" receiving an event, the yoked subject whose experimental partner is ineffective would receive many events (i.e., air puffs), and since this yoked subject is effective, he would reach a high CR level. Hence, the yoked subject in this pair would evidence more CRs than his experimental partner so that this difference might be expected to cancel out the difference in the opposite direction in the reverse mismatch case. In order to determine whether or not this would happen, one must examine the outcomes when the two difference conditioning rates are expressed in numerical terms (cf. Black, 1967).

Suppose, for example, that for effective subjects the first air puff produces one CR, the second air puff produces two CRs, the third air puff three CRs, etc... Thus, an effective avoidance subject would receive his first air puff on Trial 1, and would therefore evidence a CR on Trial 2. Since he would evidence a CR on Trial 2, he would not receive an air puff on that trial. On Trial 3, he would not evidence a CR and would therefore receive an air puff. As a result of this second air puff, he would evidence CRs on Trials 4 and 5. On Trial 6, he would receive his third air puff, and would evidence CRs on Trials 7, 8 and 9, etc... Suppose, on the other hand, that for ineffective subjects it takes three air puffs to produce the first CR, three more air puffs to produce an additional two CRs, another three air puffs to produce three more CRs, etc... Thus, an ineffective avoidance subject would receive the US on Trials 1, 2 and 3, evidence a CR on Trial 4, receive the US on Trials 5, 6 and 7, evidence CRs on Trials 8 and 9, etc... Table 1 presents the expected numbers of CRs in 100 trials for the experimental and yoked subjects in the two mismatch cases.

TABLE 1

The Expected Numbers of CRs in 100 Trials for the Experimental and Yoked Subjects in the Two Mismatch Cases.

	No. of CRs Experimental Subjects	No. of CRs Yoked Subjects	No. of Air Puffs
Effective Experimental Ineffective Yoked	87	10	13
Ineffective Experimental Effective Yoked	67	99	33
Total No. of CRs	154	109	

In the case of an effective experimental subject who is paired with an ineffective yoked partner, the experimental subject would give 87 CRs and receive 13 air puffs in the first 100 trials. For his ineffective yoked partner, 13 air puffs would be enough to produce 10 CRs. In the other case, the ineffective experimental subject would evidence 67 CRs and receive 33 air puffs. His effective yoked partner would require the first air puff to produce his first CR and thereafter would receive enough air puffs to continue evidencing CRs for the rest of the session. The total number of CRs, then, would be 154 for the experimental subjects and 109 for the yoked subjects (see Table 1). Obviously, the calculated difference in numbers of CRs between the experimental and yoked subjects in this analysis depends upon the values that one assigns to the conditioning rates.

Black (1967) presented an alternative version of the bias argument. In this version, differential conditioning rate is expressed as different numbers of trials to reach criterion. The notion here is that subjects require a certain number of CS-US pairings to reach a conditioned state after which they respond consistently to the CS, and that subjects differ in the number of CS-US pairings that they require to reach this state.

Black's argument was the following: Suppose that effective subjects require 20, and ineffective subjects 40, CS-US pairings to reach criterion. Consider, then, the four possible combinations of avoidance and yoked, effective and ineffective, subjects. In the case where both the avoidance subject and his yoked partner are effective, both would receive 20 pairings and reach criterion together. Similarly, in the ineffective-ineffective case, both would receive 40 pairings and reach criterion at the same time.

In the case where an effective avoidance subject is paired with an ineffective yoked subject, the avoidance subject would reach criterion after 20 CS-US pairings; since his ineffective yoked partner requires 40 CS-US pairings, he would not reach criterion. If, on the other hand, an ineffective avoidance subject is paired with an effective yoked subject, the avoidance subject would reach criterion after 40 CS-US pairngs; since 40 pairings are more than enough for an effective subject, his yoked partner would also reach criterion. Hence, all the avoidance subjects, but not all the yoked subjects, would reach criterion. In capsule form, the bias exists because avoidance subjects, regardless of the effectiveness of their yoked partners, "give themselves" enough CS-US pairings to reach criterion, whereas yoked subjects reach criterion only if they are as effective as, or more effective than, their avoidance partners.

Experimental Support for the Bias Argument

Because the yoking procedure has figured prominently in a large number of programs of research on instrumental contingency effects, the implications of the bias argument could be profound. Indeed, if the argument is sound, claims of instrumental contingency effects on the basis of instrumental-yoked differences become suspect. However, although several investigators have acknowledged Church's criticism of the yoked control design, few have sought to obtain experimental evidence that would bear on his argument.

Pre-yoke matching. If within-pair mismatching in effectiveness does contribute to an instrumental-yoked difference, then eliminating the mismatches should reduce the difference. The obvious way to eliminate such mismatches is to form pairs of subjects that are matched on effectiveness, and support for the bias argument would be provided if the avoidance-yoked difference were smaller in such matched pairs than in random pairs (i.e., where subjects are randomly assigned to pairs, without regard to their conditioning effectiveness). Kimmel and Sternthal (1967) used this matching strategy in their attempt to demonstrate avoidance contingency effects in human galvanic skin response (GSR) conditioning that could not be attributed to design bias.

In Kimmel and Sternthal's study, all subjects underwent a pre-yoking phase consisting of 3 US-alone (i.e., shock to the fingertips) trials, followed by 10 CS-alone (i.e., tone) and 2 CS-US trials. Matching was based on two measures of performance during the preliminary phase - "responsivity" and "conditionability". Responsivity was computed for each individual by summing his GSRs (magnitude) over the last three trials of the preliminary phase. Conditionability was computed by subtracting a subject's GSR on the second CS-US trial from his GSR on the first CS-US trial.

Out of 24 pairs of subjects, 19 were well matched on both of these measures. An analysis of variance on the CR scores for these 38 subjects indicated that the avoidance-yoked difference fell just short of the conventional level of statistical significance ($.05 < p < .10$). In view of an earlier finding (Kimmel & Baxter, 1964) that avoidance subjects produce significantly higher magnitude GSRs than yoked partners in random pairs, Kimmel and Sternthal interpreted the reduced avoidance-yoked difference in matched pairs in their study as tending to support the bias argument. However, the reduced avoidance-yoked difference may have been due to the pre-yoke treatment which they introduced in order to obtain measures of responsivity and conditionability, and not to the matching *per se*. In this regard, the authors noted that:

> "The inability to avoid on the first two acquisition trials may have interfered with the development of an avoidance response, especially since *Ss* may demonstrate attenuation of the CR very early in classical GSR conditioning (Kimmel, 1966) (pp. 145-146)."

They then suggested that eyelid conditioning, where initial CS-US trials do not produce attenuation of CRs, would be a better preparation in which to implement a pre-yoke matching strategy to test the bias argument.

Reciprocal yoking. Another procedure that has been used to examine the bias argument is the reciprocal yoking procedure described in a methodological paper by Kimmel and Terrant (1968). In this procedure, the subjects in each random pair are reciprocally yoked such that, during presentations of one CS (e.g., a tone), an instrumental contingency is in effect for one subject while the other is yoked, and during presentations of a second CS (e.g., a light), the conditioning roles are reversed. A schematic representation of this design is given in Table 2.

TABLE 2

Schematic Representation of the Reciprocal Yoked Control Design (Reproduced from Kimmel & Terrant, 1968). The Arrows Indicate the Direction of Control of Events.

	CS_A	CS_B
Subject 1	AVOIDANCE ↓	YOKED ↑
Subject 2	YOKED	AVOIDANCE

Table 2 illustrates that during CS_A presentations Subject 1 is under an avoidance contingency while Subject 2 serves as his yoked partner. During CS_B presentations, Subject 2 is under the avoidance contingency, while Subject 1 serves as his yoked partner. In this way, within-subject, as well as between-subject, avoidance-yoked contrasts are provided.

Terrant (1968) used the reciprocal yoking procedure in four separate GSR conditioning experiments involving avoidance and punishment contingencies. In all these experiments, both between-subject and within-subject contrasts failed to show an instrumental-yoked difference in CR magnitude. The explanation offered by Terrant to account for the failure to replicate the finding of a between-subject, avoidance-yoked difference (e.g., Kimmel & Baxter, 1964) was that, because his experiments were intended to examine changes in the UCR as well as the CR, the conditioning parameters that were used were not optimal for obtaining instrumental learning.

Despite the absence of any instrumental-yoked difference in his study, Terrant did provide evidence that the bias argument is not applicable to avoidance-yoked comparisons in the GSR conditioning preparation. The reader will recall that the crux of the bias argument is that, since the ineffective instrumental subject continues to receive events until it acquires the CR whereas the ineffective yoked subject stops receiving events before it acquires the CR, the ineffective instrumental subject enjoys an advantage over the ineffective yoked subject. Terrant (p. 78) noted that such an advantage was unlikely in his preparation since the ineffective avoidance subjects in his study showed no increase in CR magnitude over trials.

<u>Multiple yoking</u>. When the bias argument is applied to avoidance-yoked conditioning comparisons (see pp. 7 - 12), only one type of mismatch (i.e., effective instrumental-ineffective yoked) is expected to result in the production of more CRs by the instrumental subject than by the yoked subject. Therefore, eliminating this type of mismatch should exclude any bias favoring the instrumental group. A procedure for eliminating one type of mismatch is to yoke a group of subjects to an instrumental subject that is known to be effective, or ineffective. Maier, Anderson and Lieberman (1972) used this multiple yoking procedure to show that the instrumental-yoked differences that were obtained in the "learned helplessness" studies were not due to bias. These studies (e.g., Seligman & Maier, 1967; Maier, 1970) had found that dogs that could escape shock in a Pavlovian harness in the first phase (i.e., the escape group) were less retarded in subsequent escape/avoidance learning

in a shuttle box than their partners that received the same amounts of inescapable shock in the first phase (i.e., the yoked group).

Maier et al. endeavored to extend the generality of this finding by comparing the effects of escapable and inescapable shock on a different shock-motivated behavior. In their first experiment, they found that a group of rats that could escape shock in a wheel-turn chamber in the first phase showed significantly more shock-elicited aggression in a fighting-chamber in a subsequent phase than did their yoked partners that received the same amounts of inescapable shock in the first phase. In their second experiment, a group of 16 escape subjects was trained first; 8 subjects were then yoked to each of the two best escapers (i.e., those subjects that evidenced overall the fastest escape responses), and both groups were subsequently tested in the same manner as those in their first experiment.

The rationale for pairing the yoked subjects with the best escapers was the following: If one assumes that rats are differentially reactive to shock, then mismatching would result in some yoked subjects receiving less shock (i.e. effective escape-ineffective yoked), and some receiving more shock (i.e., ineffective escape-effective yoked), than they would if shock termination were contingent upon their own responding. Maier et al. argued that:

> "This assymetry could have more effect for subjects for which shock is effective than for subjects for which shock is ineffective since by definition they are more reactive to shock. The net result could be analogous to delivering more shock to the yoked group than to the escape group (p. 97)."

Therefore, if the likelihood of forming a pair in which the yoked subject is more effective than its escape partner were reduced, the escape-yoked difference should be smaller. However, the results of the second experiment revealed a difference in shock-elicited aggression in the test phase between the escape and yoked groups that was very similar to that obtained in the first experiment, and the authors concluded from these results that bias was not producing the difference between the groups.

In summary, the bias argument has not received much experimental support. Kimmel and Sternthal (1967) found that the avoidance-yoked difference in GSR conditioning was smaller in matched than in random pairs. However, as these investigators noted, the reduced avoidance-yoked difference may have been due to their pre-yoke manipulation. Furthermore, Terrant's (1968) finding that ineffective avoidance subjects failed to increase their CR amplitude over trials suggests that the bias argument is not applicable to avoidance-yoked comparisons in the GSR conditioning preparation. Finally, Maier, Anderson and Lieberman's (1972) finding that the escape-yoked difference was as large when all the yoked subjects were paired with the best escapers as when the yoked subjects were randomly paired with escape partners supports the contention that bias is not contributing to the instrumental-yoked difference in this paradigm.

Purpose

The purpose of the research described in this thesis was to obtain experimental evidence that would bear on the argument that bias arising from within-pair mismatching in effectiveness contributes to the avoidance-yoked difference obtained in eyelid conditioning.

CHAPTER 2

EXPERIMENT 1

Pre-Yoke Matching Study

The present experiment was designed, first, to replicate, in the rabbit eyelid conditioning preparation, the earlier finding (Moore & Gormezano, 1961; Gormezano, Moore & Deaux, 1962; Gormezano, Fluentes & Erickson, 1963; Hupka, Massaro & Moore, 1968) that, in random pairs, the avoidance group reaches a higher asymptotic CR level than the yoked group; and secondly, following Kimmel and Sternthal's (1967) suggestion, to provide a comparison of the avoidance-yoked difference in acquisition in random pairs with that in pairs that are matched on effectiveness prior to yoking.

Method

Subjects. The subjects were 72 male, New Zealand white rabbits, weighing 2-3 Kg at the start of the experiment, and were supplied by Riemens Fur Ranch, St. Agatha, Ontario. They were individually housed and given continuous access to food and water in their home cages.

Apparatus. The conditioning apparatus was a modified form of that described by Gormezano (1966; see Siegel, 1969). Conditioning took place in one of six identical sound-attenuated chambers

(72cm x 42cm x 56cm). Programming and recording equipment were located in a separate room. Each chamber was illuminated by a 7½ watt frosted bulb. Subjects were confined in restraining boxes (38cm x 17½cm x 20cm) within each chamber. In order to prevent gross head movements, the pinna were fastened in a rubber-lined clamp that was attached to the restraining box, and a bar was positioned over the subject's nose to further reduce head movements.

A rotary microtorque potentiometer (Conrac Corp., Model 85111) was mounted on the nose bar, and the shaft of the potentiometer was joined with a nylon thread and hook to a wound clip fastened to the subject's left upper eyelid. A counterweight on the shaft ensured that the thread remained taut. In this way, mechanical movements of the eye were transformed into electrical signals that were recorded on a polygraph (Oscillograph Model RD-1661-20, Brush Instruments, Division of Clevite Corp.). Each potentiometer was also connected to an optical D.C. meter (A.P.I. Instrument Co., Model 429-142R7), modified so that changes in position of the upper eyelid could be constantly monitored. In addition, the meters were set to detect eyelid closures during the CS-US interval and to trigger counters that tallied these responses for each subject. These meters were set at a very sensitive level such that eyelid closures causing any discernible deflection in the recording pen were detected. When an eyelid closure during the CS-US interval was recorded for an avoidance subject, a stop command precluded the delivery of shock on that trial to that avoidance subject and to its yoked partner.

The CS was a 500 msec, 2000 Hz tone, produced by an audio generator (Electronic Institute Co., Model 377) at an intensity of 82 db (re .0002 dynes/cm^2) in the conditioning chamber. The US was a 100 msec, 5 mA shock, generated by an A.C. shock source (Scientific Prototype, Model 4007 J). The shock was delivered through alligator clips attached to a pair of chronically implanted tantalum wire (Codman, size 4-0, 725-1017) electrodes inserted approximately 1 cm apart into the infraorbital region of the left eye. On those trials when the US was delivered, it immediately followed the termination of the CS.

Experimental design and procedure. All subjects were first given two daily sessions, 40 min each, in which to adapt to the restraint and to the apparatus. Subsequent daily sessions consisted of 20 conditioning trials. Throughout the experiment, the interval between successive CS presentations was 1, 2 or 3 min (average: 2 min), the different intervals being presented in a predetermined random order. Accordingly, the duration of each conditioning session was 40 min.

Four major groups were included in the design, with each major group composed of an avoidance group and a yoked group. The treatments given to each of these major groups are described below.

(1) Randomly paired and yoked. In this group of 18 subjects, nine pairs were randomly formed at the beginning of the experiment. Subjects were then randomly assigned to avoidance (RGroup A) and yoked (RGroup Y) conditions within each pair. All pairs were given 12 days of avoidance-yoked conditioning.

(2) Matched on 100% classical conditioning and yoked. This group consisted of 18 subjects that were given 100% classical conditioning in a preliminary phase. All subjects continued in this phase until they met (or surpassed) a criterion of four CRs in a block of 20 trials. When a subject met criterion on a particular day, it was matched for number of CRs as closely as possible with another subject that had also met criterion on that day, and the two subjects then entered the second phase on the following day as a yoked pair. Assignment to avoidance (MGroup 100%C-A) and yoked (MGroup 100%C-Y) conditions for the first pair of subjects that reached criterion was determined by the toss of a coin; the subject in subsequent pairs that reached a higher CR level than its partner on criterion day was alternately assigned to each condition. Of a possible nine pairs, eight matched pairs were eventually formed, and these eight pairs received eight days of conditioning in the avoidance-yoked phase. The two subjects that could not be matched were discontinued.

(3) Matched on avoidance conditioning and yoked. The 18 subjects in this group were matched in the same manner as those matched on 100% classical conditioning [see (2) above], except that, for these subjects, the preliminary phase consisted of avoidance conditioning. Again, of a possible nine pairs, eight matched pairs of avoidance (MGroup A-A) and yoked (MGroup A-Y) subjects were formed. Of those eight pairs, seven completed eight days of avoidance-yoked conditioning, and one was terminated after four days when one member of the pair became ill. The data from this pair were not included in the analyses.

(4) Matched on 50% classical conditioning and yoked. The preliminary phase for the 18 subjects in this major group was classical conditioning in which shocks were delivered on a predetermined 50% of the trials. The matching procedure was the same as it was for the other matched groups. Eight matched pairs of avoidance (MGroup 50%C-A) and yoked (MGroup 50%C-Y) subjects were formed in this group, but one of these was discontinued due to an equipment failure. Data analyses were performed on the scores provided by the seven pairs that completed the eight days of avoidance-yoked conditioning.

The rationales for including the four major groups were, briefly, the following. The group in which subjects were randomly paired and randomly assigned to conditions within pairs permitted a replication of the finding that, in such random pairs, the avoidance group reaches a higher asymptotic CR level than the yoked group. The avoidance-yoked difference in random pairs would also serve as a base against which to assess possible attenuation of this difference in matched pairs. Three different matched groups were included to determine whether the effects of matching were independent of the particular conditioning schedule upon which subjects were matched.

Results

Random group. The mean percent CR scores, along with plus and minus one standard error of the means[1], for the 12 days of avoidance-

[1]Plus and minus one standard error of the means are included for all group curves in the figures in this paper.

yoked conditioning for RGroup A and RGroup Y are presented in Figure 1. Two things should be noted in examining Figure 1. First, RGroup A reached a higher asymptotic CR level than RGroup Y. A Mann-Whitney U test on the mean percent CR scores over the last 4 days of conditioning indicated that this difference between groups was significant ($U=14.5$, $p < .05$, two-tailed[2]). Secondly, the between-subject variability in the number of CRs was much larger in RGroup Y than in RGroup A. This difference was confirmed statistically with an F ratio of the sum of squares computed on the scores for each of the last eight days of conditioning (Winer, 1962; $F_{max} > 4.5$ in all cases, $df=2, 8$, $p < .05$).

This large variability in the yoked group could have important implications for the bias argument. If the acquisition performance by a yoked subject were determined by whether it was more effective, or less effective, than its avoidance partner, some yoked subjects would evidence faster acquisition than their avoidance partners and quickly reach a high CR level, while others would evidence slower acquisition than their avoidance partners and remain at a low CR level. Thus, the large variability that was observed in the yoked group may have been the result of averaging the scores for these two types of subjects.

[2]Two-tailed probability values were used in all statistical pairwise comparisons in this paper.

Figure 1

Experiment 1: The mean percent CR scores for the 12 days of avoidance-yoked conditioning for the subjects that were randomly assigned to pairs at the outset and randomly assigned to avoidance (RGroup A) and yoked (RGroup Y) conditions within pairs.

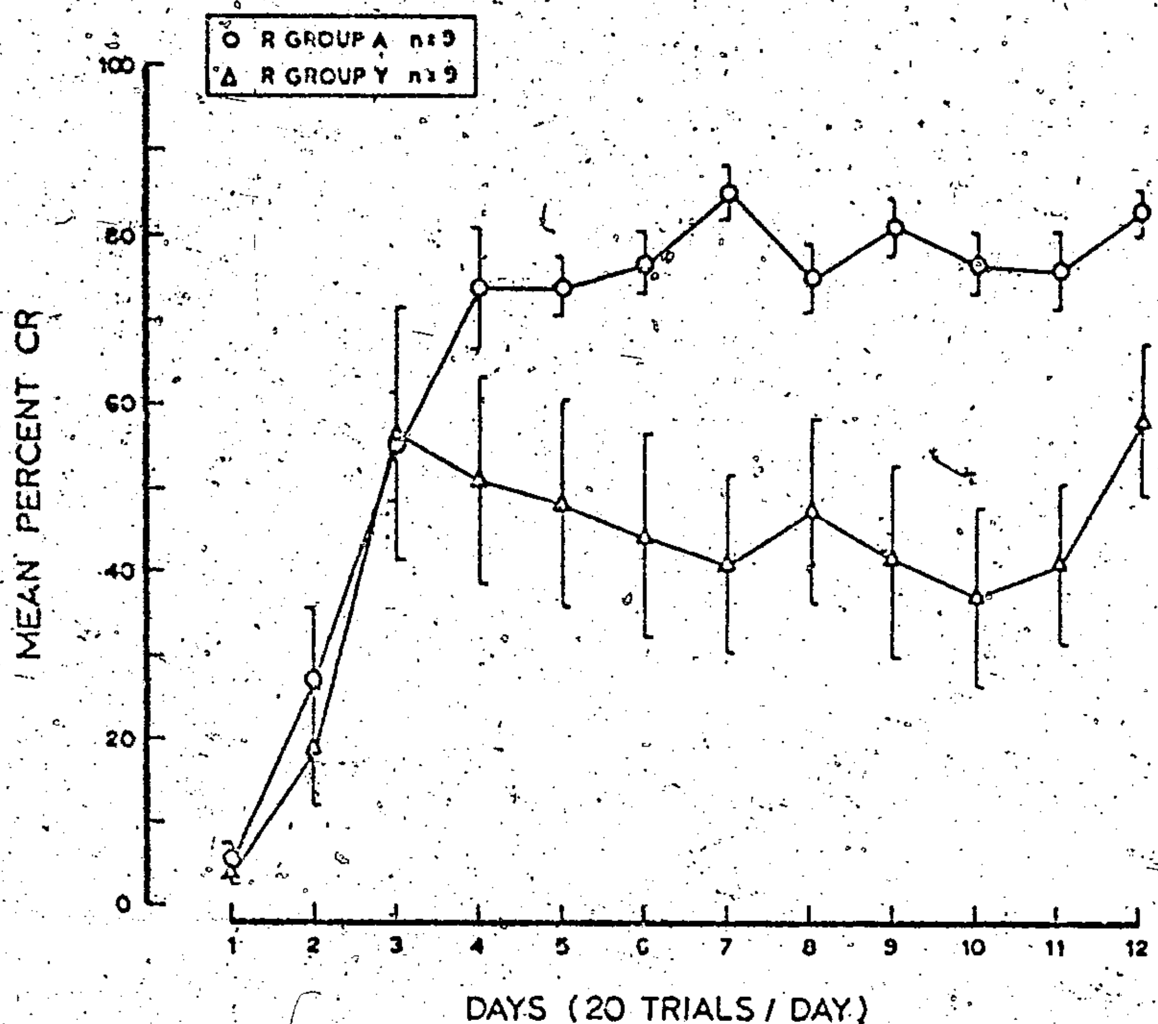

O R GROUP A n=9
Δ R GROUP Y n=9
MEAN PERCENT CR
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
DAYS (20 TRIALS / DAY)

Figure 1

As a measure of acquisition rate, the number of trials to reach a criterion of eight CRs in a block of 10 trials was computed for each subject. In five of these nine random pairs, the yoked subject reached this criterion <u>before</u> its avoidance partner, and in the other four pairs, the yoked subject reached it <u>after</u> its avoidance partner, or not at all. The mean percent CR scores for these two subgroups of yoked subjects, along with those for the avoidance group, are presented in Figure 2. Figure 2 shows that the subgroup of five yoked subjects that evidenced faster acquisition than their respective avoidance partners, labeled "Type 1" yoked subjects, reached a 90% CR level on Day 3. Some of these subjects maintained this level, while others decreased their number of CRs so that the average on subsequent days declined to about 50%. Figure 2 also shows that the subgroup of four yoked subjects that evidenced slower acquistion than their respective avoidance partners, labeled "Type 2" yoked subjects, increased their number of CRs very slowly, and eventually reached a mean CR level of 40%.

If the Type 1 subgroup comprised the yoked subjects that were more effective than their avoidance partners, then, since they would continue to receive shocks for some number of trials after they had begun to evidence CRs (unlike avoidance subjects that stop receiving shocks consistently once they have begun to evidence CRs), the extended classical conditioning might produce higher CR scores in these subjects than those ever reached by their avoidance partners. Figure 2 shows that, consistent with this expectation, the Type 1 subgroup

Figure 2

Experiment 1: The mean percent CR scores for the two subgroups of yoked subjects (RGroup Y) in the random pairs. One subgroup comprises the yoked subjects (n=5; labeled "Type 1") that evidenced faster acquisition than their respective avoidance partners; the other subgroup comprises the yoked subjects (n=4; labeled "Type 2") that evidenced slower acquisition than their respective avoidance partners. The mean percent CR scores for the avoidance subjects (RGroup A) are also included.

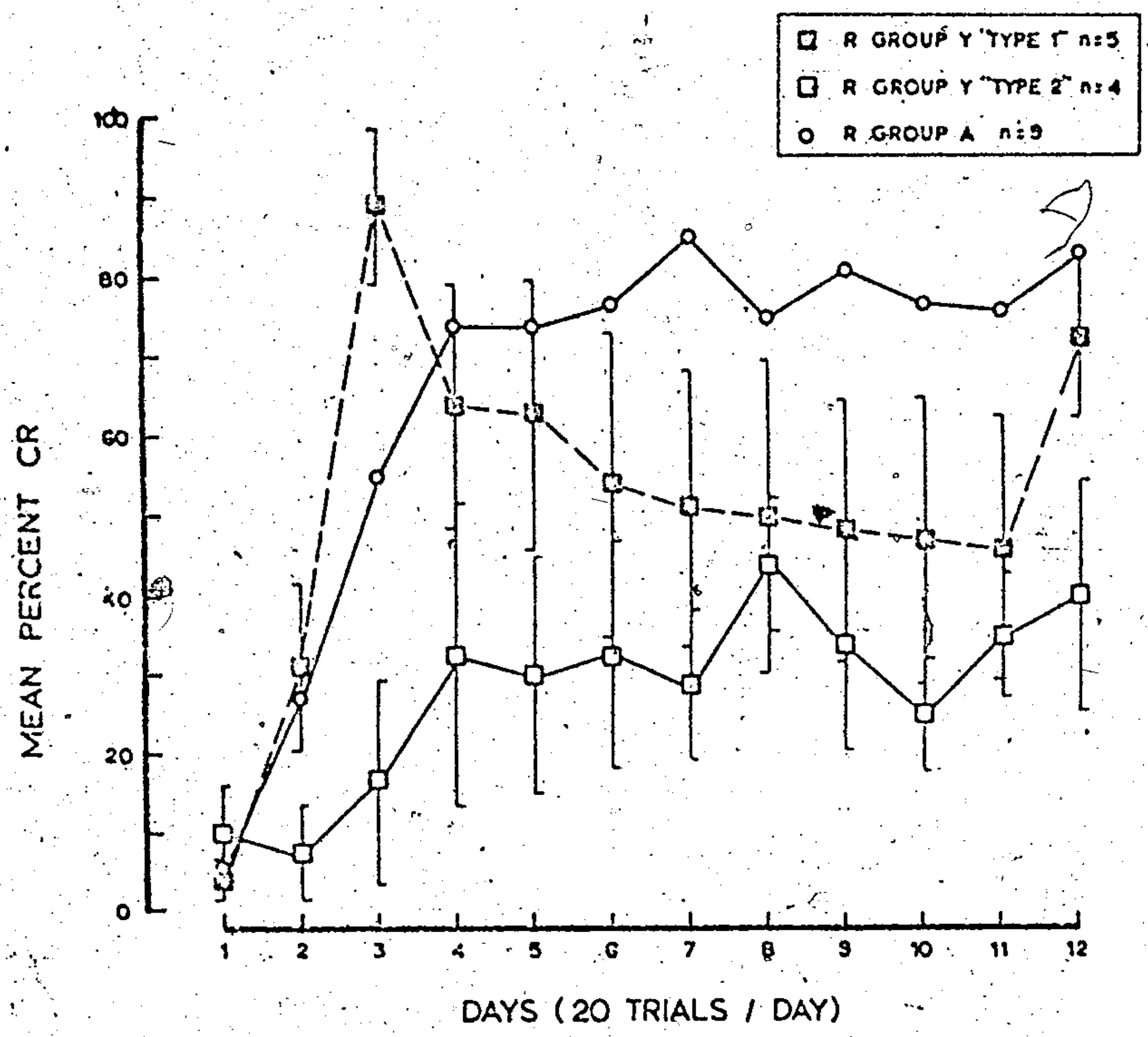

R GROUP Y "TYPE 1" n=5
R GROUP Y "TYPE 2" n=4
R GROUP A n=9
MEAN PERCENT CR
0
20
40
60
80
100
1
2
3
4
5
6
7
8
9
10
11
12
DAYS (20 TRIALS / DAY)

Figure 2

reached a higher CR level on Day 3 than that ever reached by the avoidance group. Furthermore, when the highest CR score for a single day was identified for each subject, within-pair comparisons revealed that, in four of the five pairs, this score was higher for the Type 1 yoked subject than for its avoidance partner.

If the Type 2 subgroup comprised the yoked subjects that were less effective than their avoidance partners, then, since they would be put under an increasingly severe, partial classical reinforcement schedule before they had begun to evidence CRs (unlike avoidance subjects that continue to receive shocks until they begin to evidence CRs), the deleterious effects of this schedule might result in their never reaching as high a CR level as that reached by their avoidance partners. Consistent with this expectation, Figure 2 shows that the Type 2 subgroup remained at a lower CR level than the avoidance group throughout conditioning. Also, examination of the data for individual pairs revealed that, in three of the four pairs, the highest CR score for a single day was lower for the Type 2 yoked subject than for its avoidance partner.

Matched groups. The mean percent CR scores on criterion day for the avoidance and yoked groups that were matched on 100% classical conditioning, avoidance and 50% classical conditioning were 70% and 70%, 43% and 45%, and 49% and 51%, respectively, while the mean percent absolute, within-pair differences on criterion day for these major groups were 11%, 8% and 16%, respectively. Figures 3, 4 and 5 present

Figure 3.

Experiment 1: The mean percent CR scores on criterion day and the eight days of avoidance-yoked conditioning for the avoidance (MGroup 100%C-A) and yoked (MGroup 100%C-Y) subjects that were matched on 100% classical conditioning.

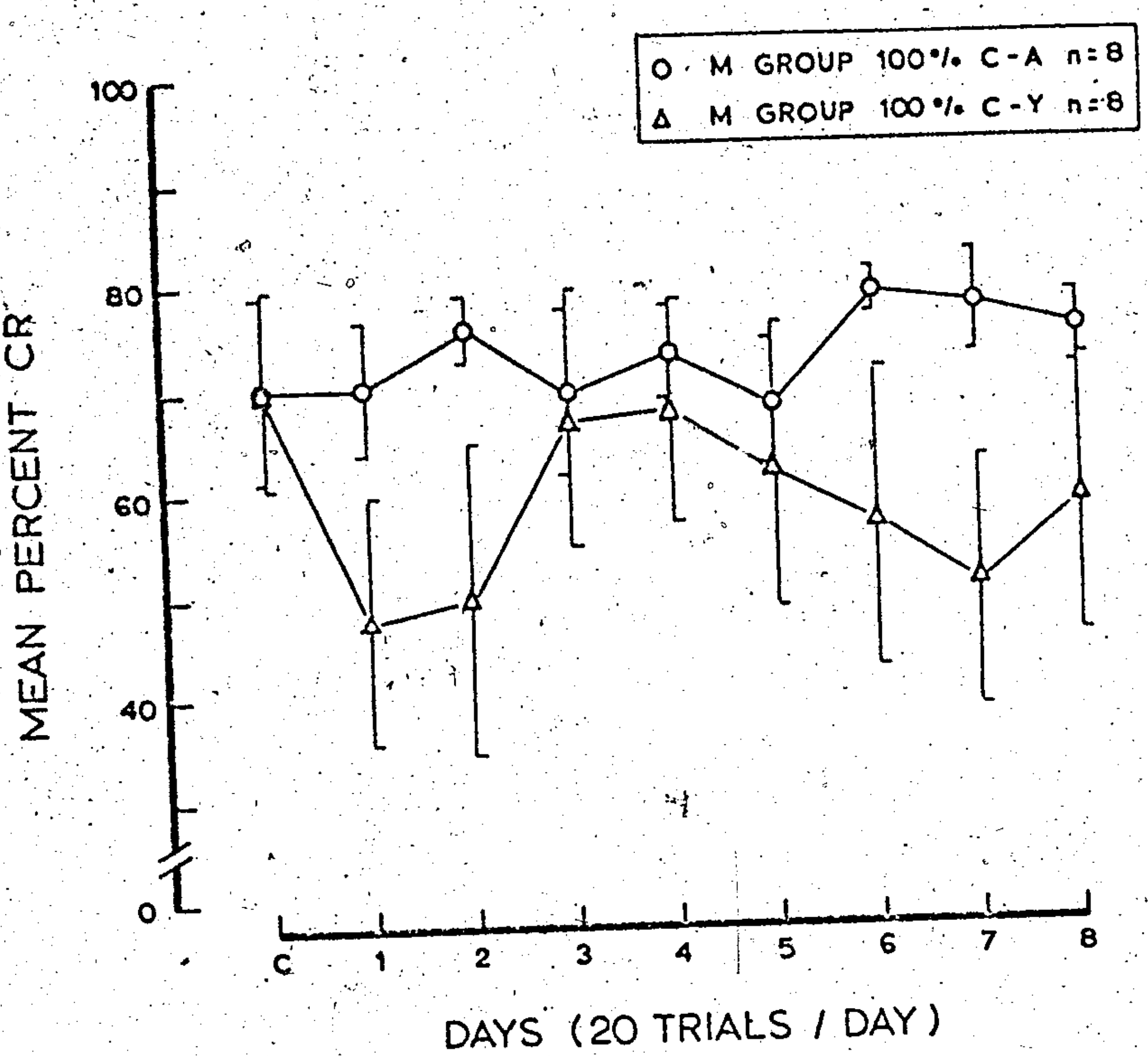

O M GROUP 100% C-A n=8
Δ M GROUP 100% C-Y n=8
MEAN PERCENT CR
100
80
60
40
0
C
1
2
3
4
5
6
7
8
DAYS (20 TRIALS / DAY)

Figure 3

Figure 4

Experiment 1: The mean percent CR scores on criterion day and the eight days of avoidance-yoked conditioning for the avoidance (MGroup A-A) and yoked (MGroup A-Y) subjects that were matched on avoidance conditioning.

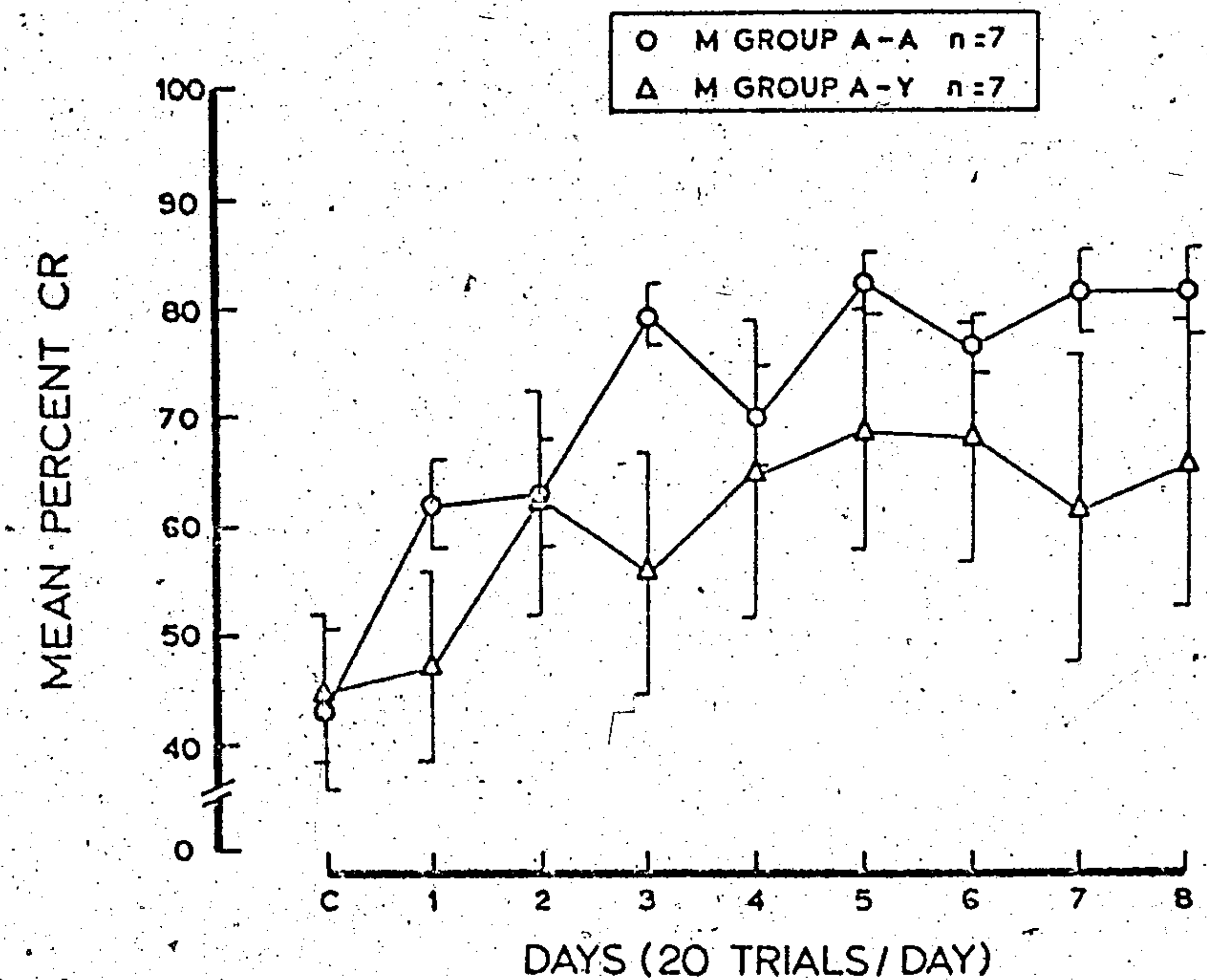

O M GROUP A-A n:7
Δ M GROUP A-Y n:7
MEAN·PERCENT CR
100
90
80
70
60
50
40
0
C
1
2
3
4
5
6
7
8
DAYS (20 TRIALS/DAY)

Figure 4

Figure 5

Experiment 1: The mean percent CR scores on criterion day and the eight days of avoidance-yoked conditioning for the avoidance (MGroup 50%C-A) and yoked (MGroup 50%C-Y) subjects that were matched on classical conditioning with a random 50% reinforcement schedule.

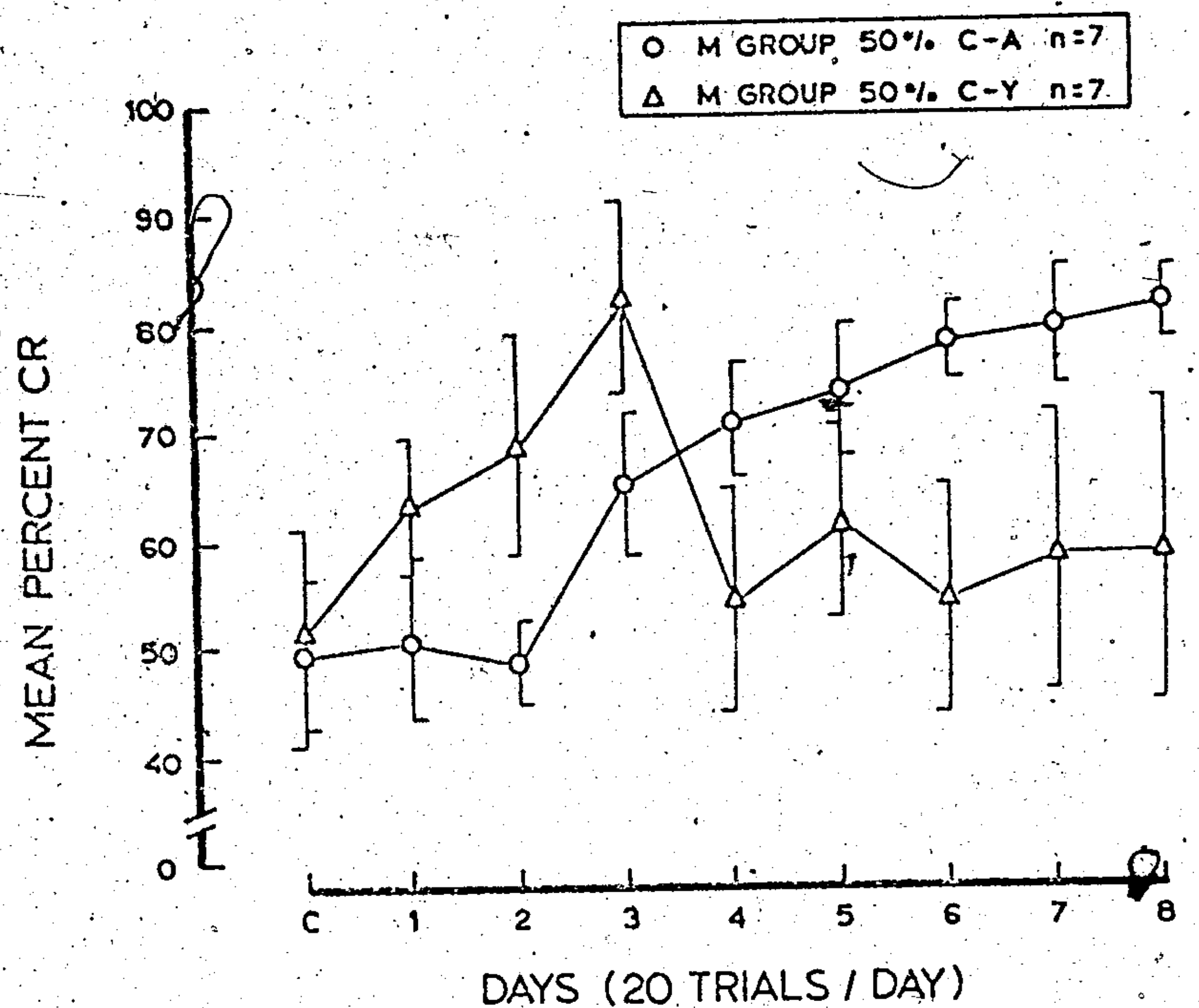

O M GROUP 50% C-A n=7
Δ M GROUP 50% C-Y n=7
MEAN PERCENT CR
100
90
80
70
60
50
40
0
C
1
2
3
4
5
6
7
8
DAYS (20 TRIALS / DAY)

Figure 5

the mean percent CR scores for these avoidance and yoked groups on criterion day and the eight days of avoidance-yoked conditioning. These figures show that the avoidance-yoked difference in each of these groups of matched pairs was smaller than that obtained in the random pairs (see Figure 1). Mann-Whitney $\underline{U}$ tests on the mean percent CR scores for the last four days of conditioning indicated that the avoidance-yoked difference did not reach statistical significance in two of these matched groups (MGroup 100%C-A & -Y: $\underline{U}=19$, $\underline{p} > .10$; MGroup A-A & -Y: $\underline{U}=21$, $\underline{p} > .10$), and approached statistical significance in the third group (MGroup 50%C-A & -Y: $\underline{U}=9.5$, $.05 < \underline{p} < .10$).

Since most of the subjects in these matched groups reached the criterion of eight CRs in a block of 10 trials <u>before</u> they entered the avoidance-yoked phase, it was not possible to compare rates of acquisition during avoidance-yoked conditioning, and to identify Type 1 and Type 2 yoked subjects in these groups.

<u>Mimicking analysis</u>. Logan (1960, p. 143) noted that a potential problem with the yoked control procedure is that the contingency between the response and the event, programmed for the experimental subject, may inadvertently obtain for the yoked subject. For example, in the eyelid conditioning preparation, if a yoked subject evidenced a CR on every trial that its avoidance partner did, and failed to evidence a CR on every trial that its avoidance partner failed to do so, the avoidance contingency would be as much in effect for the yoked subject as for the avoidance subject. Such a correlation be-

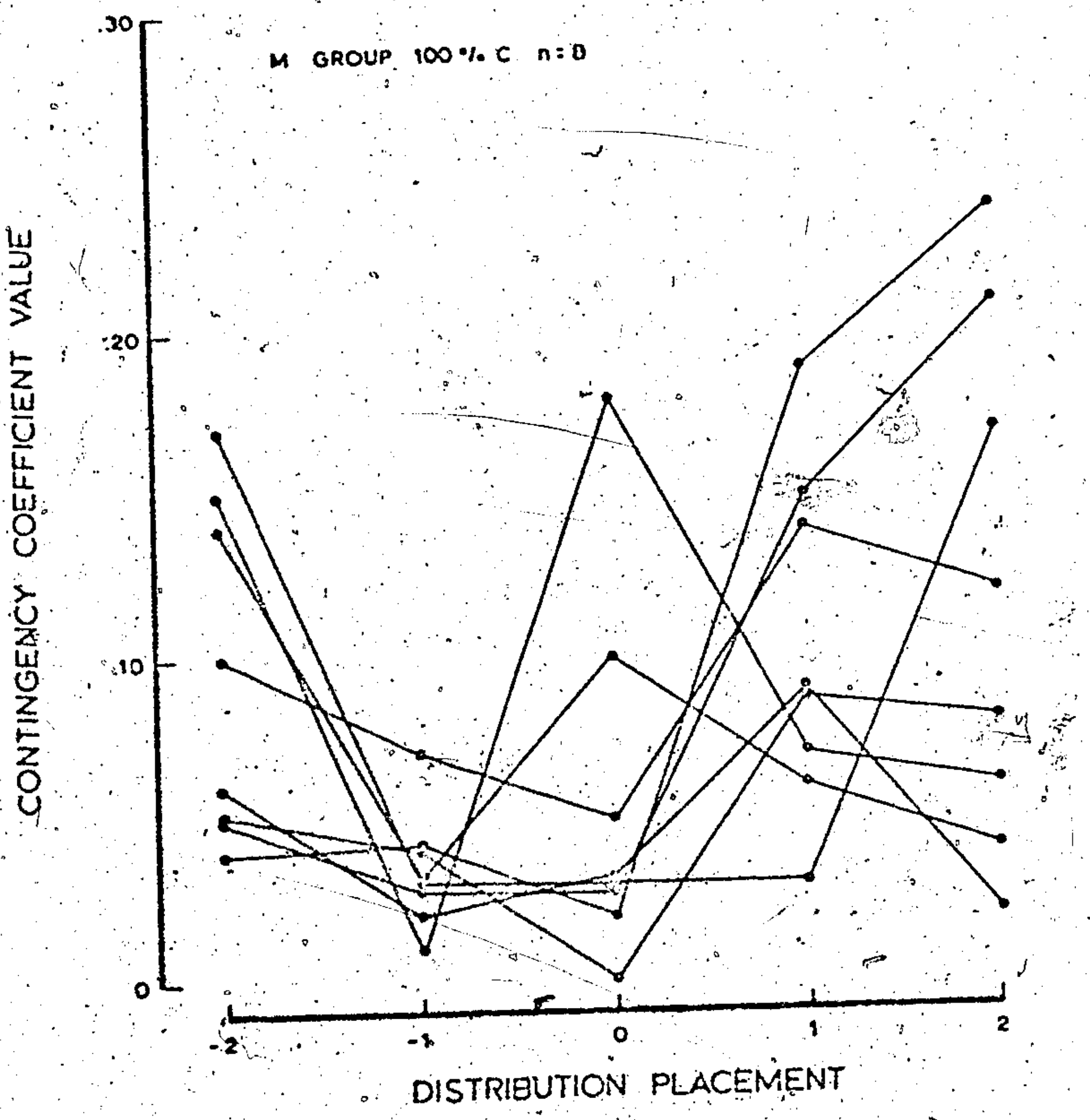
tween the CR patterns of the yoked and avoidance subjects in the random pairs in the present experiment was very unlikely in view of the extremely different rates of acquisition in the two type of yoked subjects in these pairs. However, a correlation of this sort may have obtained in the matched pairs. Indeed, if the attempt to match the subjects on conditioning effectiveness were successful, one might expect that the same number and pattern of shocks would produce similar patterns of CRs in the subjects in each pair.

In order to test the possibility that inadvertent avoidance contingencies obtained for the yoked subjects in the matched pairs, a contingency coefficient of the CRs over the 160 trials was computed for each of the pairs in the three matched groups. As a basis for comparison, contingency coefficient values were also computed with the CR pattern of the yoked subject displaced by 1 and 2 trials relative to that of the avoidance subject. If the CR pattern of a yoked subject were mimicking the CR pattern of its avoidance partner, the contingency coefficient value for the pair would be high for the actual joint outcomes, and would be lower when the CR patterns were displaced.

Figures 6, 7 and 8 present the contingency coefficient values at the five placements for each pair in the three matched groups. These figures show that there was no tendency for the values to peak at the 0 placement. In fact, only 5 pairs recorded their highest coefficient values at the 0 placement; with 22 pairs and five placement points, such an outcome would be expected by chance.

Figure 6

Experiment 1: The contingency coefficient values computed on the actual joint CR outcomes, and with the CR pattern of the yoked subject displaced by 1 and 2 trials in both directions relative to that of the avoidance subject, for the eight pairs that were matched on 100% classical conditioning (MGroup 100%C).



M GROUP 100 % C n = 8
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 6

Figure 7

Experiment 1: The contingency coefficient values computed on the actual joint CR outcomes, and with the CR pattern of the yoked subject displaced by 1 and 2 trials in both directions relative to that of the avoidance subject, for the seven pairs that were matched on avoidance conditioning (MGroup A).

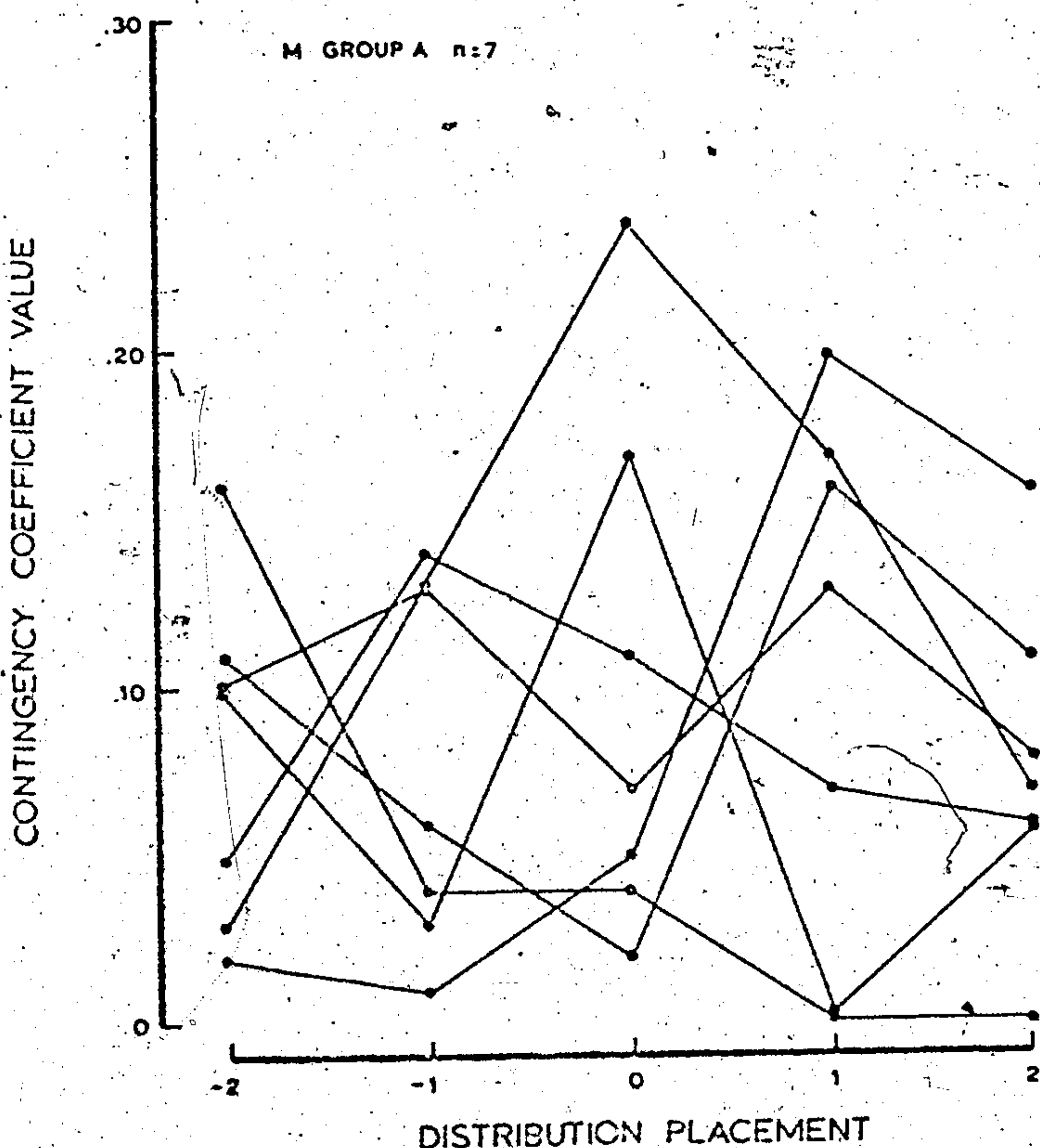

M GROUP A n:7
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 7

Figure 8

Experiment 1: The contingency coefficient values computed on the actual joint CR outcomes, and with the CR pattern of the yoked subject displaced by 1 and 2 trials in both directions relative to that of the avoidance subject, for the seven pairs that were matched on classical conditioning with a random 50% reinforcement schedule (MGroup 50%C).

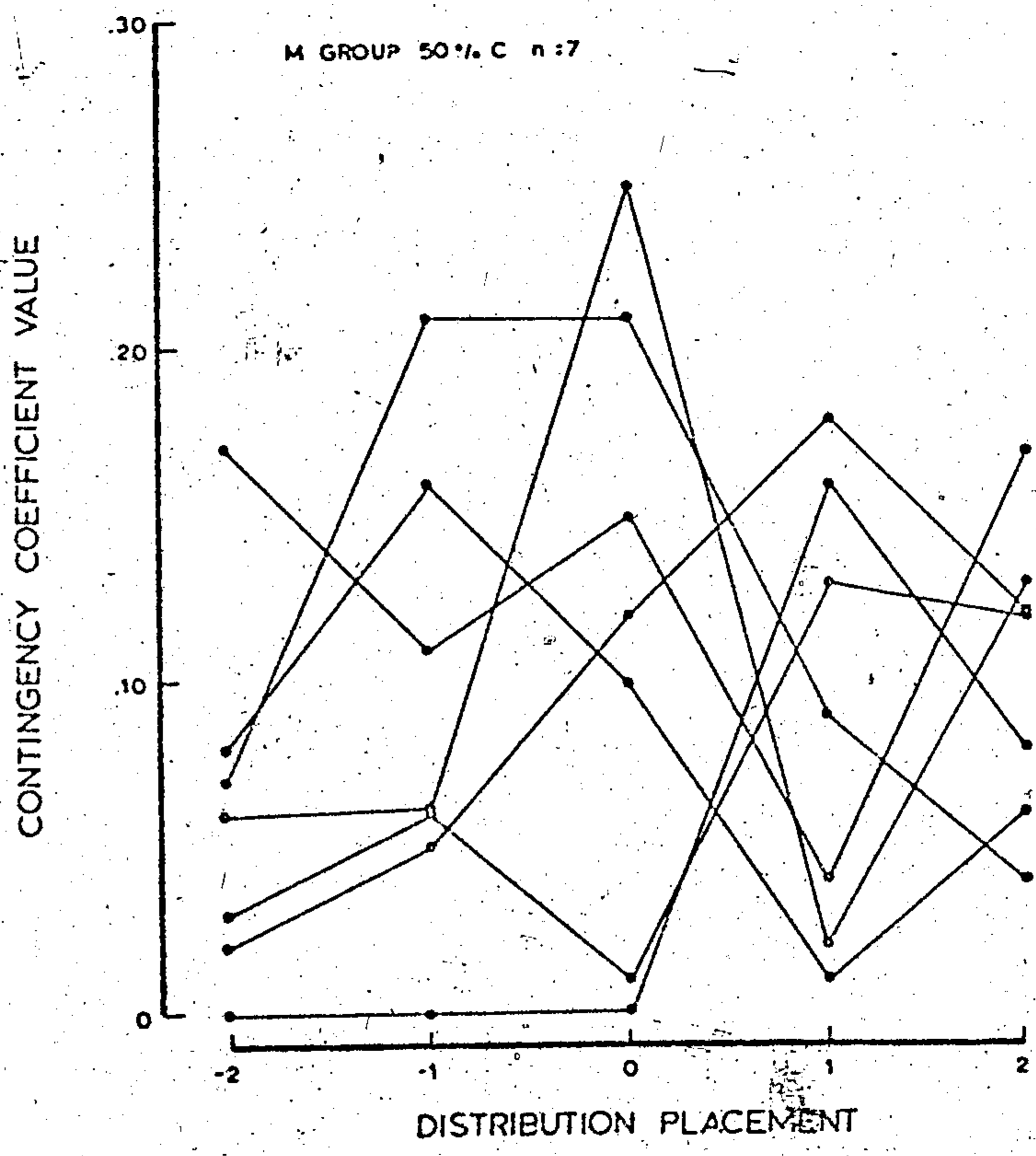

M GROUP 50% C n:7
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 8

Discussion

Although the results indicated that the avoidance-yoked difference was smaller in the matched groups that in the random group, this finding does not provide unequivocal support for the bias argument. Indeed, the avoidance-yoked difference may have been smaller in the matched groups because most of the subjects in these groups, unlike those in the random group, had reached a high CR level before they entered the avoidance-yoked phase. Kimmel and Sternthal (1967) were most likely referring to this dilemma in using the matching procedure in this preparation when they commented:

> "The problem may be insoluble, however, since subjects would have to be given enough classical conditioning trials to obtain an estimate of conditionability and more trials would be necessary for the eyelid reflex than for the GSR (p. 146)."

The present study did provide a replication of the finding that, in random pairs, the avoidance group reaches a higher asymptotic CR level than the yoked group (Moore & Gormezano, 1961; Gormezano, Moore & Deaux, 1962; Gormezano, Fluentes & Erickson, 1963; Hupka, Massaro & Moore, 1968). This finding, by itself, might suggest that acquisition performance by avoidance subjects was generally superior to that of the yoked subjects. However, this was not the case. Examination of the data for individual subjects revealed that about half the yoked subjects (labeled Type 1) acquired the CR faster than their respective avoidance partners, and it was the failure of some of these yoked subjects to maintain a high CR level, combined with the failure of the other yoked subjects (labeled Type 2) to reach a high CR level, that resulted in the difference between groups late in training.

The finding that the yoked subjects could be readily divided into two types of subjects is particularly interesting since the acquisition performance that characterized these two types was consistent with expectations based on the notion that these subjects represented yoked subjects that were more effective (Type 1), and less effective (Type 2), than their avoidance partners. Furthermore, the proportions of each type, 5/9 and 4/9, corresponded well to the proportions of more effective and less effective yoked subjects that would be expected with random pairing and random assignment to conditions within pairs.

CHAPTER 3

EXPERIMENT 2

Multiple Yoking Study

The results of Experiment 1 indicated that, in random pairs, there are two types of yoked subjects, and it was suggested that these two types might represent subjects that are more effective (Type 1) and less effective (Type 2) than their avoidance partners. The present experiment was designed to further examine the possibility that the dichotomous performance of these yoked subjects is the result of two types of mismatching.

The logic of the experiment was the following: Since an avoidance subject determines, through its own responding, the number of shocks it receives, and since conditioning effectiveness is a measure of the number of shocks that a subject requires in order to acquire the CR, the number of shocks that an individual under the avoidance contingency takes to acquire the CR is an index of its conditioning effectiveness. Therefore, if the nine avoidance subjects in RGroup A in Experiment 1 (see Chapter, 2, p. 22) were ranked according to how many shocks they received during acquisition, they would also be ranked on conditioning effectiveness. Accordingly, the subject that received the fewest shocks would provide an estimate of a highly effective subject, an estimate of average conditioning effectiveness would be provided by the median avoidance subject, and so on. Hence, if a group of subjects were yoked to any one of these nine avoidance subjects, the proportions of yoked subjects that would be more effective, and less effective, than the avoidance subject could be estimated from the latter's ranking in the group. And, if relative effectiveness were reflected in subject type, the observed proportions of Type 1 and Type 2 subjects would match the expected proportions of more effective and less effective yoked subjects.

Method

Subjects. The subjects were 12 rabbits of the same age, sex and strain as those used in Experiment 1 (see Chapter 2, p.20).

Apparatus. The apparatus was identical to that used in Experiment 1 (see Chapter 2, pp. 20-22).

Experimental design and procedure. The nine subjects in Group A in Experiment 1 (see Chapter 2, p. 22) were ranked according to how many shocks they took to reach the criterion of eight CRs in a block of 10 trials. The subject that took the fewest shocks was ranked first, and the one that took the most shocks was ranked ninth. One of these subjects, the third ranking, was arbitrarily selected, and his protocol determined the exact schedule of shocks delivered to the 12 subjects in this study.

Results

The mean percent CR scores for the 12 days of conditioning for the yoked group as well as the percent CR scores for the selected avoider are presented in Figure 9. Figure 9 shows that overall the

CR scores for the selected avoider were higher than the mean CR scores for the yoked group.

Examination of the individual data revealed that 4 of the 12 yoked subjects reached the criterion of eight CRs in a block of 10 trials before the selected avoider, and the other 8 yoked subjects reached this criterion after the selected avoider, or not at all. Mean percent CR scores for these Type 1 (n=4) and Type 2 (n=8) subgroups of the yoked group, along with the CR curve for the selected avoider, are presented in Figure 10. Figure 10 shows that the Type 1 subgroup, like the one in Experiment 1 (see Chapter 2, Figure 2, p. 30), acquired the CR quickly but failed to maintain a high average CR level subsequently, and 2) that the Type 2 subgroup, like the one in Experiment 1, acquired the CR slowly and reached a low asymptotic level. Further examination of the individual data revealed that there was a tendency, though not as marked as in Experiment 1, for the Type 1 subjects to reach highest daily CR scores that were higher, and for Type 2 subjects to reach highest daily CR scores that were lower, than that reached by the avoidance subject. Specifically, 2 of the 4 Type 1 subjects evidenced scores that were higher, and 6 of the 8 Type 2 subjects evidenced scores that were lower, than that of the selected avoider.

Discussion

The results of this study indicated that the proportions of Type 1, and Type 2, subjects in the group that was yoked to the selected

Figure 9

Experiment 2: The mean percent CR scores for the 12 yoked subjects, and the percent CR scores for the selected avoider, for the 12 days of avoidance-yoked conditioning.

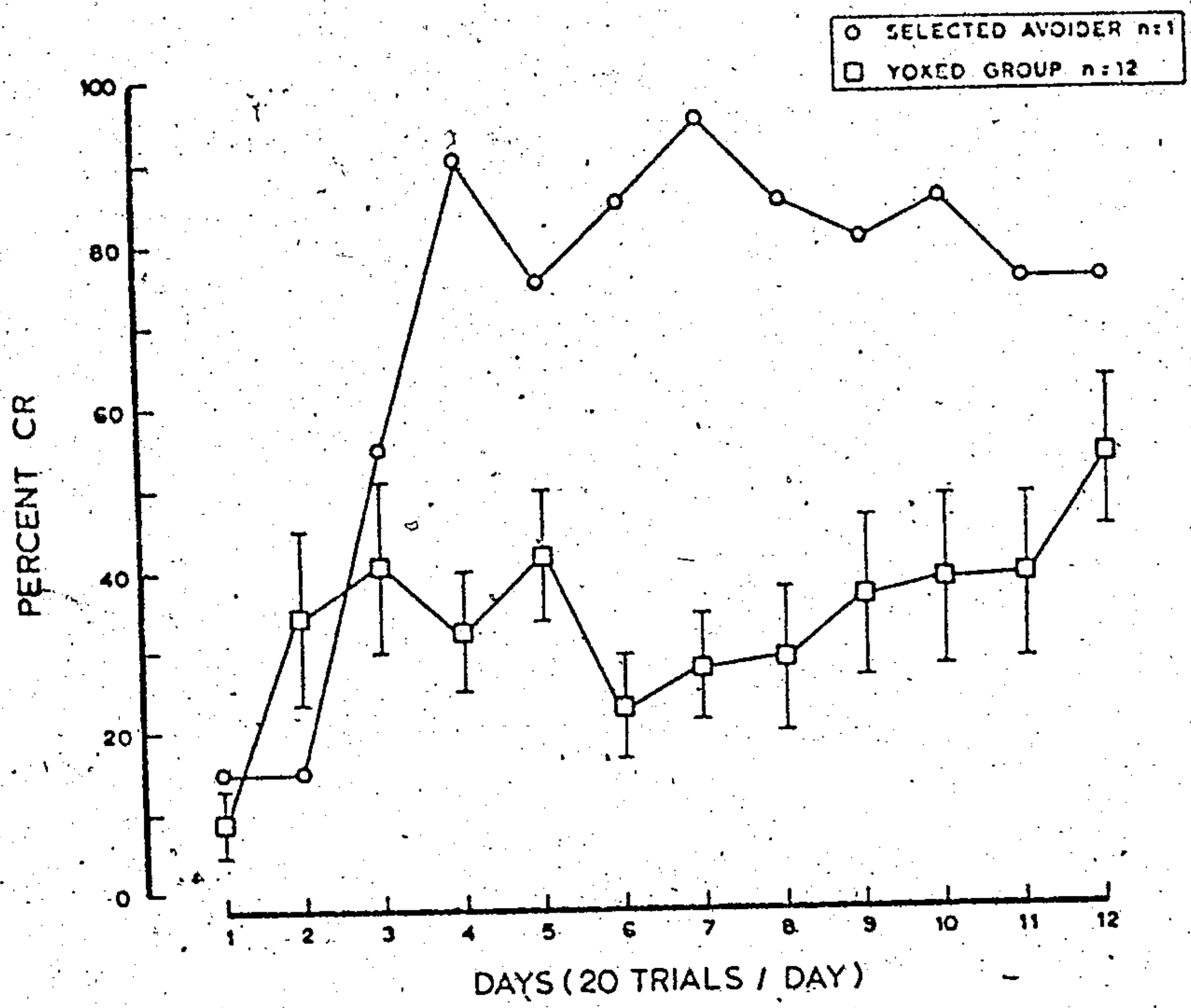

SELECTED AVOIDER n:1
YOXED GROUP n:12
PERCENT CR
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
DAYS (20 TRIALS / DAY)

Figure 9

Figure 10

Experiment 2: The mean percent CR scores for the Type 1 (n=4) and Type 2 (n=8) subgroups of yoked subjects. The percent CR scores for the selected avoider are also included.

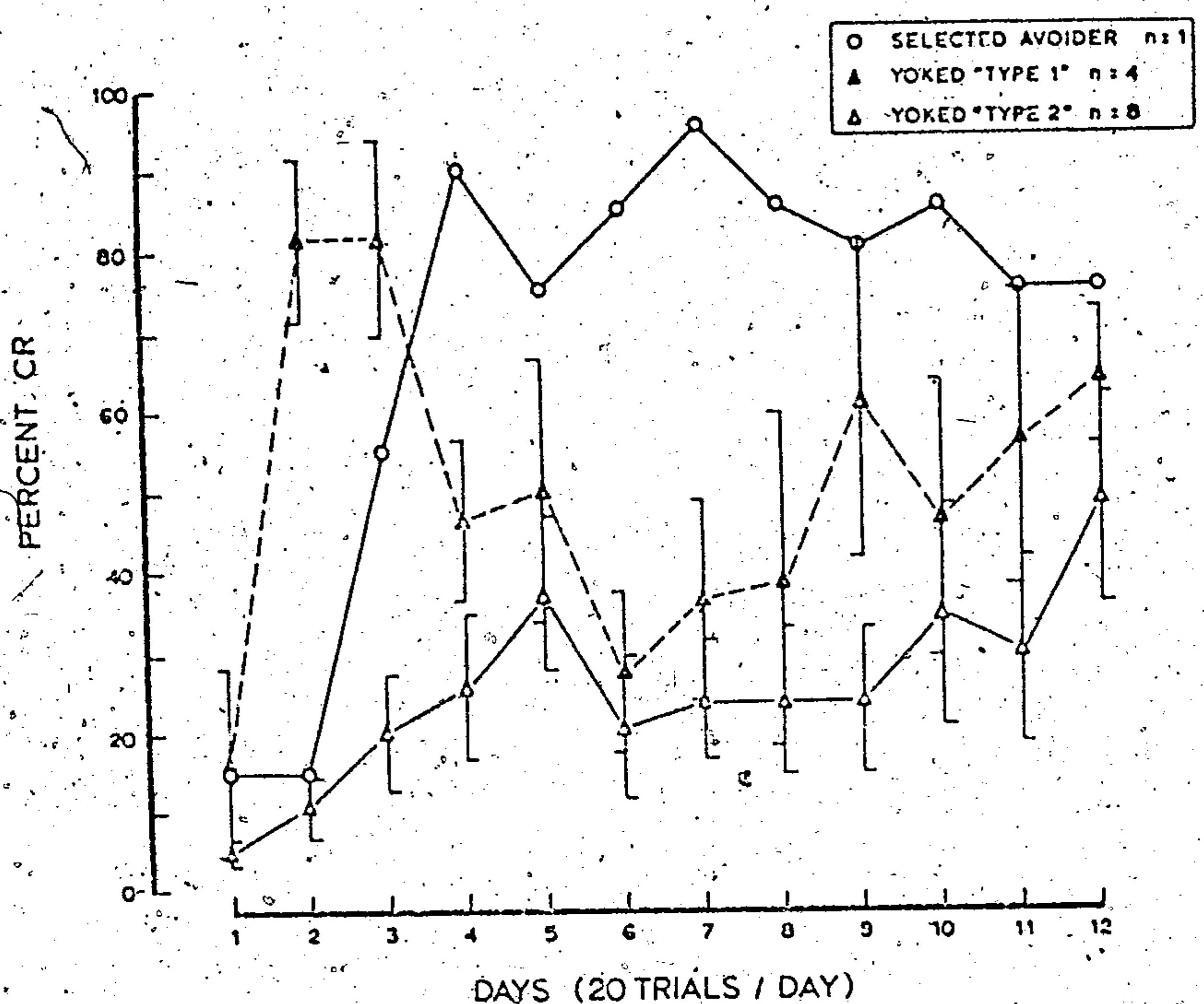

SELECTED AVOIDER n = 1
YOKED "TYPE 1" n = 4
YOKED "TYPE 2" n = 8
PERCENT CR
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
DAYS (20 TRIALS / DAY)

Figure 10

avoider were 4/12, and 8/12, respectively. Since these proportions correspond well to the proportions of more effective and less effective yoked partners that would be expected on the basis of the avoidance subject's ranking (i.e., third in a group of nine avoidance subjects), these results provide support for the notion that relative effectiveness is reflected in yoked subject type.

CHAPTER 4

EXPERIMENT 3

Reciprocal Yoking and Self-Yoking Study

The experiments described in Chapters 2 and 3 provided between-subject contrasts that permitted an assessment of a yoked subject's conditioning effectiveness relative to that of its avoidance partner. A yoked subject that acquired the CR more quickly than its avoidance partner was judged to be more effective, and a yoked subject that acquired the CR more slowly was judged to be less effective, than its avoidance partner. Support for these judgments was provided by the finding in each experiment that the proportions of yoked subjects that evidenced faster and slower, acquisition than their avoidance partners corresponded well to the proportions of yoked subjects that were expected to be more effective and less effective, respectively, than their avoidance partners.

An additional finding in these experiments was that the yoked subjects that were judged to be more effective than their avoidance partners tended to reach higher CR levels during acquisition than those ever reached by their avoidance partners. This finding suggests that the extra shocks that they received (which, presumably, they would not have experienced if they had been under the avoidance contingency) produced additional CRs in these yoked subjects. Similarly, the finding that the yoked subjects that were judged to be less effective than their avoidance partners tended to remain at lower CR levels than their avoidance partners suggests that the absence of a number of shocks (which, presumably, they would have experienced if they had been under the avoidance contingency) resulted in a decreased number of CRs in these yoked subjects. Accordingly, if one were to arrange a within-subject, avoidance-yoked contrast in which a given subject received more shocks during acquisition in its yoked condition than in its avoidance condition, it should evidence more CRs in the former than in the latter; and, if it received fewer shocks during acquisition in its yoked condition than in its avoidance condition, it should evidence fewer CRs in the former than in the latter. The reciprocal yoking procedure (see Chapter 1, pp. 14-16) provides these two kinds of within-subject contrasts, and this procedure was used in this experiment to test these two predictions.

In addition to within-subject contrasts in which a subject receives more, or fewer, shocks in one condition than in the other, one could arrange a within-subject contrast in which the subject receives the same number of shocks in both conditions. One procedure that affords this kind of contrast is the self-yoking procedure, in which the number and pattern of events that are taken by a subject under an instrumental contingency are subsequently given to it in a yoked phase. A few experimenters (Hilstead, Baer & Fuhrer, 1968; Payne, 1972) have used the self-yoking procedure to circumvent the possible bias effects in between-subject comparisons. In the present study, this procedure was used to test the prediction that a subject that was given the same number and pattern of shocks in its yoked condition as it experienced in its avoidance condition would evidence comparable numbers of CRs in the two conditions.

Method

Subjects. The subjects were 144 rabbits of the same age, sex and strain as those used in Experiments 1 and 2.

Apparatus. The only change in the apparatus (see Chapter 2, pp. 20-22) was the addition of circuitry for extinguishing the houselights for brief durations.

Experimental design and procedure for reciprocal yoking. The reciprocal yoking procedure (Kimmel & Terrant, 1968) involves two CSs. During presentations of one CS, an instrumental contingency is in effect for one subject of a pair while its partner is yoked to it, and during presentations of the other CS, the conditioning roles are reversed. In this way, each subject is the instrumental subject under one CS and the yoked subject under the other CS, so that a comparison of an individual subject's performance under the two CSs provides a within-subject instrumental-yoked contrast. Furthermore, if subjects are randomly assigned to reciprocal pairs, one would expect one subject to be more effective than its partner, so that the pair would receive more USs in association with one CS (i.e., when the instrumental contingency is in effect for the less effective subject) than the other CS (i.e., when the instrumental contingency is in effect for the more effective subject). Accordingly, each reciprocal pair would yield a within-subject, instrumental-yoked contrast in which a subject (the more effective) received more CS-US pairings in its yoked condition than in its instrumental condition, and a within-subject, instrumental-yoked contrast in which a subject (the less effective) received fewer shocks in its yoked condition than in its instrumental condition.

A potential problem with the reciprocal yoking procedure is that conditioning to one CS will influence conditioning to the other CS, thereby complicating interpretations of any difference in the number of CRs to the two CSs. Several precautions were taken to reduce the likelihood that conditioning to one CS would influence conditioning to the other CS in this study. First, two USs were used instead of one. Since the unconditioned eyelid-closure response is unilateral in rabbits (Gormezano, 1966), and since the results of a pilot study suggested that conditioning involving shock to one eye proceeded independently of conditioning involving shock to the other eye, shock to the left eye was associated with one CS and shock to the right eye was associated with the other CS. Furthermore, the shock intensity was reduced (from 5 mA to 2 mA) to insure that response elicitation would be restricted to the shocked eye. Also, rather than presenting the CSs concurrently within the same sessions as in Terrant's (1968) procedure, the two CSs, each associated with a different US, were presented in separate phases. Finally, there was a six-week interval between the end of Phase I and the beginning of Phase II.

The two CSs and two USs that were used in the present study were the following: CS_T was the same 500 msec, 2000 Hz tone that was used in the two previously described experiments; CS_L was a 500 msec offset of the 7½ watt bulb that otherwise served as the houselight in the conditioning chamber; US_L was a 100 msec, 2 mA shock to the left eye; US_R was an identical shock to the right eye.

Ninety-six subjects were randomly divided into four sets of 24 subjects. The conditioning stimuli that were used in Phase I and Phase II for each of these four sets are presented in Table 3. Table 3 shows that these four sets provided counterbalanced presentations of all combinations of CSs and USs (with the restriction that each CS and US was given to a subject in only one phase).

TABLE 3

Conditioning Stimuli in Phase I and Phase II for the Four Sets of Subjects in the Reciprocal Yoking and Self-Yoking Parts of This Study.

Set	Phase I Conditioning Stimuli	Phase II Conditioning Stimuli
1	CS_T-US_L	CS_L-US_R
2	CS_T-US_R	CS_L-US_L
3	CS_L-US_L	CS_T-US_R
4	CS_L-US_R	CS_T-US_L

In each set of 24 subjects, 6 subjects were randomly assigned to each of four groups. Two of these groups were experimental groups that received six days (20 trials/day) of avoidance conditioning in one phase and six days (20 trials/day) of yoked conditioning in the other. The other two groups were control groups that were restrained (i.e., neither a CS nor a US was presented) in Phase I and given six days (20 trials/day) of avoidance or yoked conditioning in Phase II. Table 4 presents the treatments that were given in Phase I and Phase II to each of these four groups.

TABLE 4

Treatments Given in Phase I and Phase II to Each of the Four Groups (in each set) in the Reciprocal Yoking Part of This Study. The Arrows Indicate the Direction of Control of Shocks. The Names That are Used to Refer to These Groups in Phase I and Phase II Are Given in Parentheses.

Group	Phase I Treatment	Phase II Treatment
1	AVOIDANCE (Avoidance I) →	→ YOKED (Yoked II)
2	→ YOKED (Yoked I)	AVOIDANCE (Avoidance II) →
3	RESTRAINT	→ YOKED (Yoked-Control)
4	RESTRAINT	AVOIDANCE (Avoidance-Control) →

The arrows in Table 4 indicate that Groups 1 and 2, the experimental groups, were reciprocally yoked such that each subject in Group 1 had a partner in Group 2 that was yoked to it in Phase I and to which it was yoked in Phase II. That is, the avoidance contingency was in effect in Phase I for a subject in Group 1 (Avoidance I) while its partner in Group 2 was yoked (Yoked I); and the avoidance contingency was in effect in Phase II for the subject in Group 2 (Avoidance II) while its partner in Group 1 was yoked (Yoked II). Groups 3 and 4 were the control groups that were restrained in Phase I and were given yoked and avoidance conditioning, respectively, in Phase II. Each subject in Group 3 was yoked in Phase II to a subject in Group 2, and since each subject in Group 1 was also yoked in Phase II to a subject in Group 2, comparisons of Phase II performance between Groups 1 and 3 (i.e., between Yoked II and Yoked-Control) provided an assessment of the transfer effects of avoidance conditioning on subsequent yoked conditioning. Similarly, comparisons of Phase II performance between Groups 2 and 4 (i.e., between Avoidance II and Avoidance-Control) provided an assessment of the transfer effects of yoked conditioning on subsequent avoidance conditioning.

Experimental design and procedure for self-yoking. In the ~~self-yoking part of this~~ study, there were also four sets of subjects, and the conditioning stimuli that were used in Phase I and Phase II for these four sets were the same as those used for the four sets in the reciprocal yoking part (see Table 3). Here, there were two groups of six subjects in each set. The treatments that were given in Phase I and Phase II to each of these groups are presented in Table 5.

TABLE 5

Treatments Given in Phase I and Phase II to the Self-Yoked and Avoidance-Avoidance-Control Groups in the Self-Yoking Part of This Study. The Arrow Indicates the Direction of Control of Shocks.

Group	Phase I Treatment		Phase II Treatment
Self-Yoked	AVOIDANCE	⟶	YOKED
Avoidance-Avoidance-Control	AVOIDANCE		AVOIDANCE

For a subject in the Self-Yoked group, the avoidance contingency was in effect in Phase I. In Phase II, each of these subjects received a yoked condition in which shock was delivered on the trials corresponding to those on which it was delivered in Phase I. Thus, for example, if one of these subjects evidenced a CR on the 14th trial on Day 1 in Phase I, thereby precluding the delivery of the shock to it on that trial, shock was not delivered to this subject on the 14th trial on Day 1 in Phase II.

As a control for order of treatments, one would have wanted a self-yoked group that received its yoked condition in Phase I and its avoidance condition in Phase II. Unfortunately, such counterbalancing was impossible since the protocol of shocks for the yoked treatment was necessarily obtained from a subject's performance in the avoidance condition. Instead, a control group that received avoidance conditioning in both phases was included in each set. Since the Self-Yoked and Avoidance-Avoidance-Control groups in each set received the same treatment in Phase I, Phase II comparisons permitted an assessment of the efficacy of yoked conditioning on a self-generated schedule of shocks relative to that of conditioning under a second avoidance contingency.

Results

Reciprocal-yoking: between-subject, avoidance-yoked contrasts. The mean percent CR scores for the six days of conditioning for the Avoidance I and Yoked I groups in the four sets of reciprocally-yoked pairs are presented in Figure 11. This figure shows that in all cases the number of CRs was greater in the avoidance group than in the yoked group. Mann-Whitney U tests on the mean percent CR scores for the last three days of conditioning indicated that the avoidance-yoked difference did not reach statistical significance in two of the four sets (CS_T-US_R: $U=7.5$, $p > .10$; CS_L-US_L: $U=14$, $p > .10$), and approached statistical significance in the other two sets (CS_T-US_L: $U=7$, $.05 < p < .10$; CS_L-US_R: $U=6$, $.05 < p < .10$). However, when the four tests of the difference between avoidance and yoked groups were combined according to Winer's (1962, p. 43) procedure for combining independent tests of the same hypothesis, an overall significant avoidance-yoked difference was obtained ($\chi^2=16.7$, $df=8$, $p < .05$).

Examination of the data for individual pairs indicated that, like the random pairs in Experiment I, some yoked subjects in these random

Figure 11

Experiment 3: The mean percent CR scores for the six days of conditioning in Phase I for the avoidance (Avoidance I) and yoked (Yoked I) groups in the four sets of reciprocal pairs.

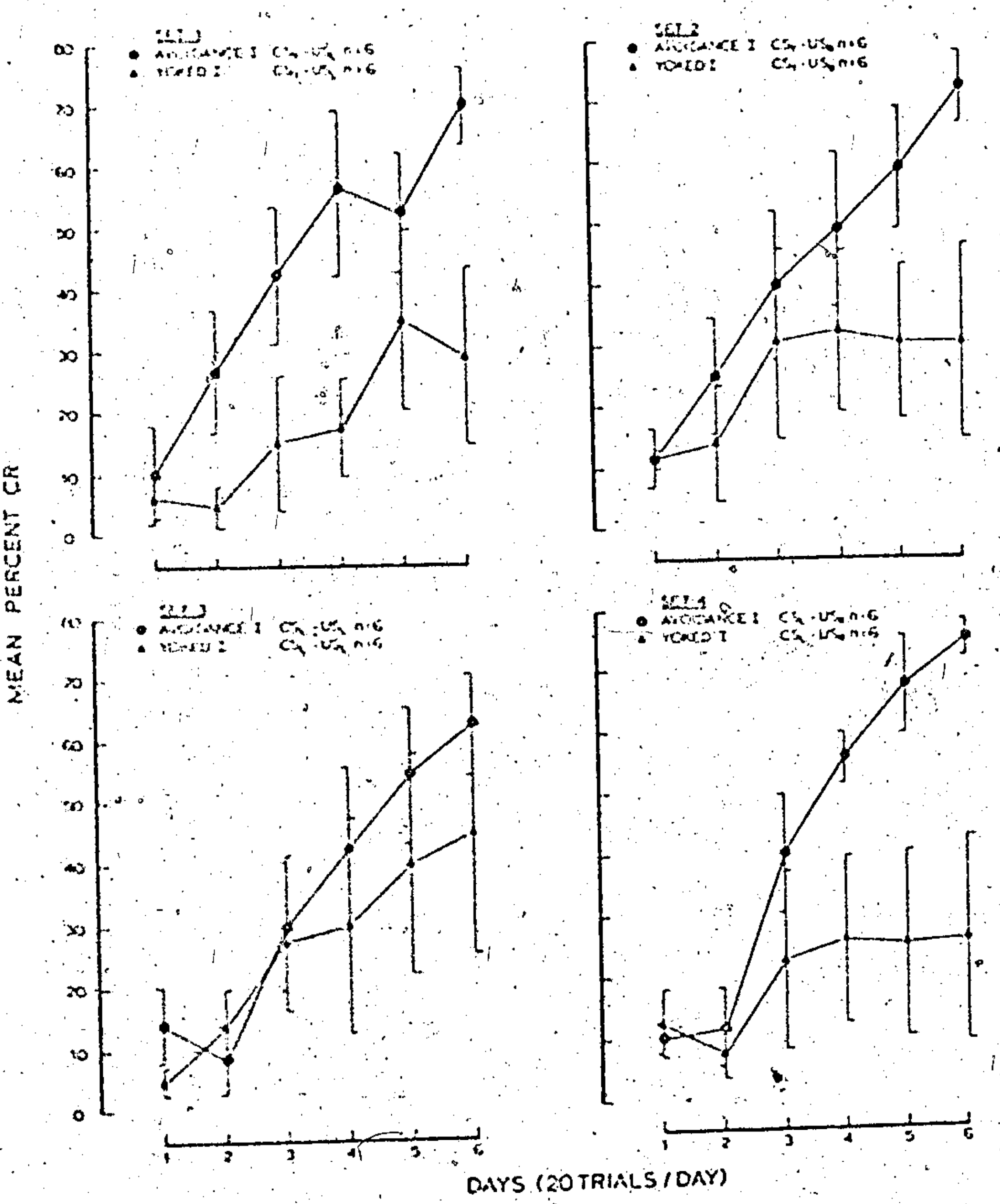

SET 1
AVOIDANCE I
YOKED I
SET 2
SET 3
SET 4
MEAN PERCENT CR
DAYS (20 TRIALS / DAY)

Figure 11

pairs evidenced faster acquisition, and others evidenced slower acquisition, than their avoidance partners. Table 6 presents the numbers of pairs, in each set, in which the yoked subject reached the criterion of eight CRs in a block of 10 trials in Phase I before its avoidance partner (i.e., Type 1 yoked subject), and after its avoidance partner or not at all (i.e., Type 2 yoked subject).

TABLE 6

Numbers of Reciprocally-Yoked Pairs, in Each Set, in Which the Yoked Subject Reached the Criterion of Eight CRs in a Block of 10 Trials in Phase I before its Avoidance Partner (Type 1), and after its Avoidance Partner or not at All (Type 2).

Set		Before (Type 1)	After (Type 2)	Neither reached criterion
1	CS_T-US_L	2	4	0
2	CS_T-US_R	2	3	1
3	CS_L-US_L	2	3	1
4	CS_L-US_R	1	5	0

Table 6 shows that, in each set, there were fewer Type 1 than Type 2 yoked subjects in Phase I, and that overall there were 7 Type 1 and 15 Type 2 yoked subjects. Further within-pair comparisons revealed that every one of these 7 Type 1-yoked subjects reached highest single daily CR scores that were <u>higher</u> than those ever reached by their respective avoidance partners, and that 14 of these 15 Type 2 yoked subjects reached highest single daily CR scores that were lower than those reached by their respective avoidance partners.

The results of between-subject, avoidance-yoked contrasts in Phase II in these reciprocally-yoked pairs were very similar to those obtained in Phase I. The numbers of Type 1 and Type 2 yoked subjects in each set in Phase II are presented in Table 7.

TABLE 7

Numbers of Reciprocally-Yoked Pairs, in Each Set, in Which the Yoked Subject Reached the Criterion of Eight CRs in a Block of 10 Trials ~~in Phase~~ II before its Avoidance Partner (Type 1), and after its Avoidance Partner or not at All (Type 2).

Set		Before (Type 1)	After (Type 2)	Neither reached criterion
1	CS_L-US_R	2	4	0
2	CS_L-US_L	2	3	1
3	CS_T-US_R	2	4	0
4	CS_T-US_L	1	5	0

Table 7 shows that, as was the case in Phase I, there were fewer Type 1 than Type 2 yoked subjects in each set; and that, overall there were 7 Type 1 and 16 Type 2 yoked subjects. Furthermore, all 7 Type 1 yoked subjects reached highest single daily CR scores that were higher than those reached by their respective avoidance partners, and

14 of these 16 Type 2 yoked subjects reached highest single daily CR scores that were <u>lower</u> than those reached by their respective avoidance partners.

Although the above Phase I and Phase II between-subject contrasts are based on data from the same groups of subjects in each set, the reader will recall that the assignments to avoidance and yoked conditions within each pair were reversed in the two phases. Therefore, if the finding that there were fewer Type 1 than Type 2 yoked subjects in Phase I had been due to a sampling error that yielded fewer mismatches in which the yoked subject was more effective than its avoidance partner than mismatches in which the yoked subject was less effective than its avoidance partner, then this sampling error would have operated in the opposite direction in Phase II. However, the proportions of Type 1 subjects in Phase I and Phase II were almost identical (i.e., 7/22 and 7/23). A test of the difference between the observed proportion (i.e., 7/22) and the expected proportion (i.e., 11/22) of Type 1 yoked subjects in Phase I indicated that this difference approached statistical significance ($Z=1.71$, $.05 < p < .10$). A similar test of the difference between the observed and expected proportions of Type 1 subjects in Phase II indicated that this difference also approached statistical significance ($Z=1.89$, $.05 < p < .10$). It appears, then, that some yoked subjects that were more effective than their avoidance partners acquired the CR more slowly than their avoidance partners.

<u>Transfer and CS effects</u>. Before performing within-subject, avoidance-yoked contrasts (which must be made across phases), it is

important to determine whether there were any effects of conditioning in Phase I on subsequent conditioning in Phase II. Figure 12 presents the mean percent CR scores for the Yoked II and Yoked-Control groups in each set. In examining this figure, the reader will notice that there was a tendency for the subjects in the Yoked II groups to evidence more CRs than the subjects in the Yoked-Control groups. This indicates that there was some positive transfer from avoidance to yoked conditioning, although pairwise comparisons of mean percent CR scores for the last three days of conditioning did not reveal significant differences, in separate analyses (CS_L-US_R: U=16, p > .10; CS_L-US_L: U=13.5, p > .10; CS_T-US_R: U=16.5, p > .10; CS_T-US_L: U=13.5, p > .10), or when the four tests were combined (χ^2=[illegible], df=8, p > .10).

The mean percent CR scores for the six days of conditioning for the Avoidance II and Avoidance-Control groups in the four sets are presented in Figure 13. This figure shows that the subjects in the Avoidance II groups evidenced more CRs than those in the Avoidance-Control groups, indicating positive transfer from yoked to avoidance conditioning. Again, the transfer effect was small, and comparisons of mean percent CR scores for the last three days of conditioning did not show significant differences, in separate analyses (CS_L-US_R: U=12, p > .10; CS_L-US_L: U=15, p > .10; CS_T-US_R: U=9, p > .10; CS_T-US_L: U=14.5, p > .10), or when the four tests were combined (χ^2=6.7, df=8, p > .10).

Since, as Figure 13 indicates, there was some positive transfer from yoked conditioning in Phase I to avoidance conditioning in Phase II,

Figure 12

Experiment 3: The mean percent CR scores for the six days of conditioning in Phase II for the reciprocal subjects (Yoked II) and the control subjects (Yoked-Control) that received yoked conditioning in that phase.

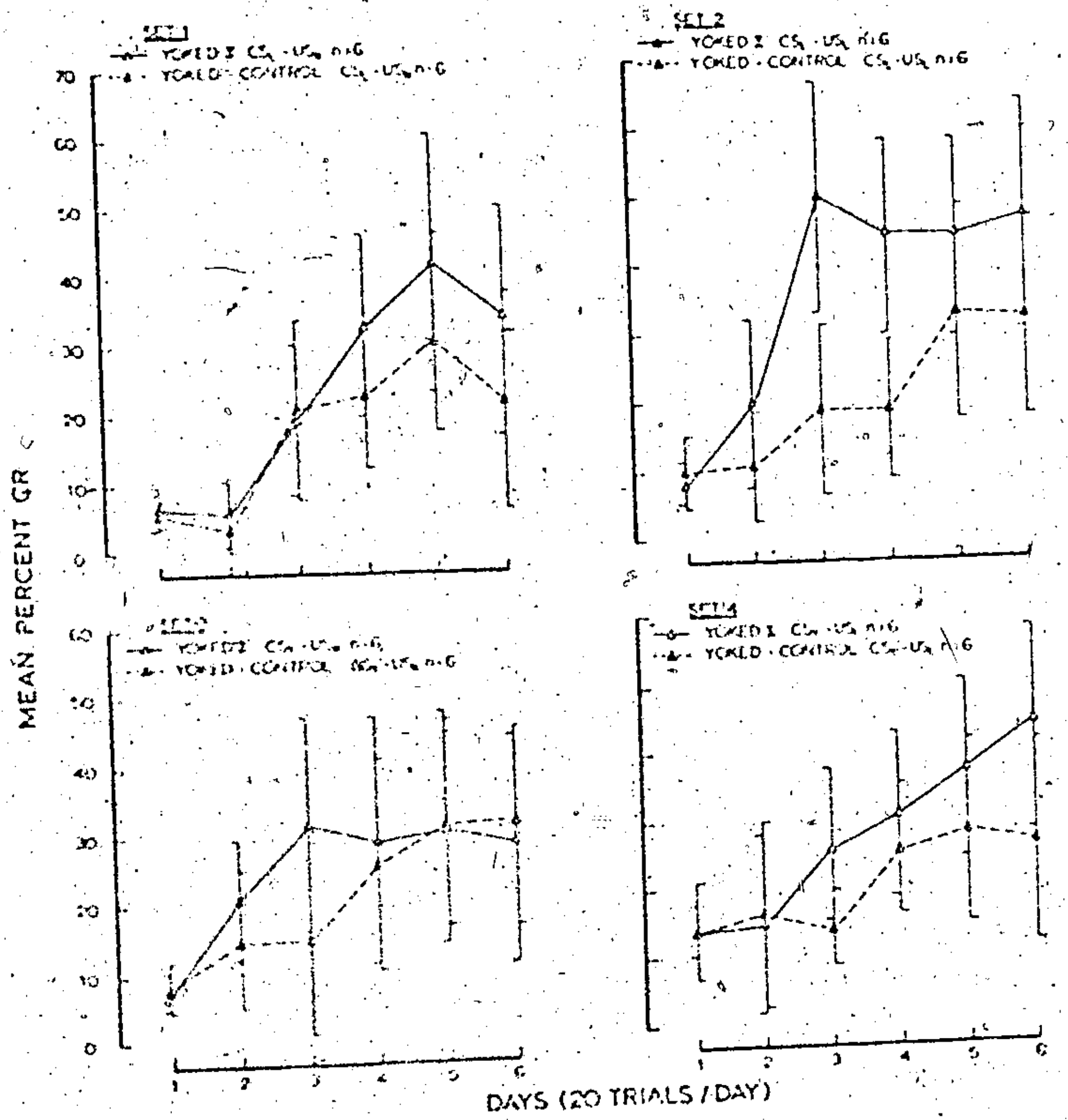


Figure 12

Figure 13

Experiment 3: The mean percent CR scores for the six days of conditioning in Phase II for the reciprocal subjects (Avoidance II) and the control subjects (Avoidance-Control) that received avoidance conditioning in that phase.

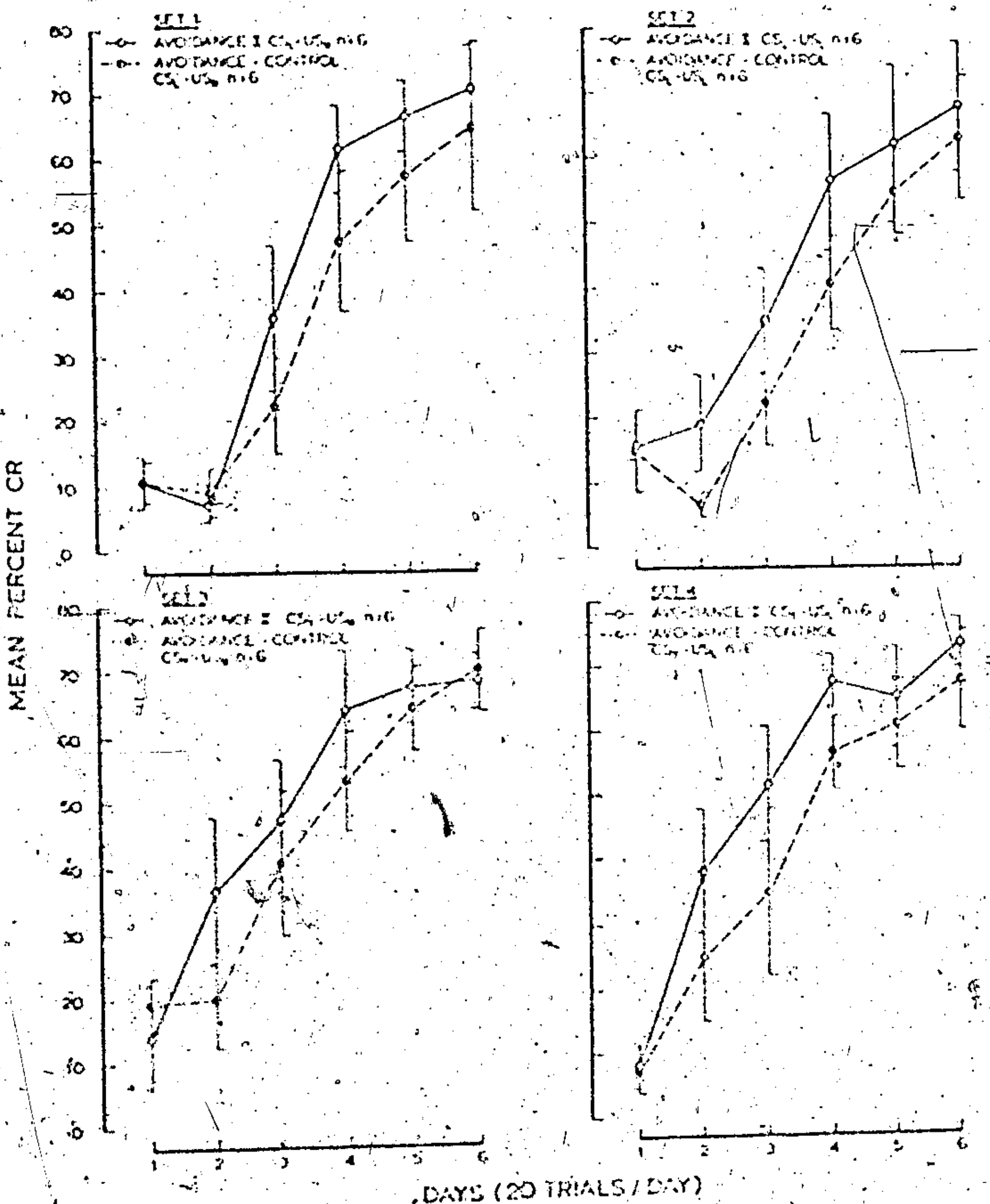


Figure 13

one would expect that, in a majority of reciprocal pairs, the Avoidance II subject would evidence more CRs than the Avoidance I subject. Table 8 presents, for the six reciprocal pairs in each set, the numbers of pairs in which the Avoidance II subject evidenced more CRs than, fewer than, and the same number as, the Avoidance I subject.

TABLE 8

The Numbers of Pairs, in the Four Sets of Reciprocal Pairs, in Which the Avoidance II Subject Evidenced More CRs than, Fewer than, and the Same Number as, the Avoidance I Subject.

Set	Avoidance I	Avoidance II	More	Fewer	Same
1	CS_T-US_L	CS_L-US_R	2	3	1
2	CS_T-US_R	CS_L-US_L	3	3	0
3	CS_L-US_L	CS_T-US_R	4	2	0
4	CS_L-US_R	CS_T-US_L	5	1	0

Table 8 shows that 1) in those pairs that received conditioning with the tone in the first phase and the light in the second phase (i.e., Sets 1 and 2), the number of pairs in which the Avoidance II subject evidenced more CRs than the Avoidance I subject was about the same as the number of pairs in which the Avoidance II subject evidenced fewer CRs than the Avoidance I subject, and 2) in those pairs that received conditioning with the light in the first phase and the tone in the second phase (i.e., Sets 3 and 4), there were more pairs in which the Avoidance

II subject evidenced more CRs than the Avoidance I subject than pairs in which the Avoidance II subject evidenced fewer CRs than the Avoidance I subject.

This difference between pairs that were shifted from tone to light and those that were shifted from light to tone is at first surprising, since similar transfer effects obtained in both cases (see Figure 13). However, this difference could be explained if avoidance conditioning were generally better with the tone than with the light. Then, the transfer effect would be counteracted by a CS effect in those pairs that were shifted from tone to light, while both effects would favor the Avoidance II subjects in those pairs that were shifted from light to tone.

In order to evaluate whether avoidance conditioning was better with one CS than with the other, all the groups that were given avoidance conditioning with the tone in the first phase were combined to form one group, and all those that were given avoidance conditioning with the light in the first phase were combined to form a second group. These groups (n=36/group) included the subjects from the Avoidance I, the Self-Yoked, and the Avoidance-Avoidance-Control groups. The mean percent CR scores for the six days of conditioning for these combined groups are presented in Figure 14. Figure 14 shows that there was a tendency for avoidance acquisition to be faster with the tone than with the light.

<u>Reciprocal yoking: within-subject, avoidance-yoked contrasts.</u> The numbers of subjects, in each set of reciprocally-yoked pairs, that received more, and fewer, shocks in their yoked condition than in their

Figure 14

Experiment 3: The mean percent CR scores for the six days of conditioning for the combined groups of avoidance subjects that received conditioning in Phase I with the tone (i.e., CS_T) and with the light (i.e., CS_L). These combined groups (n=36/group) included the Avoidance I, the Self-Yoked, and the Avoidance-Avoidance-Control subjects.

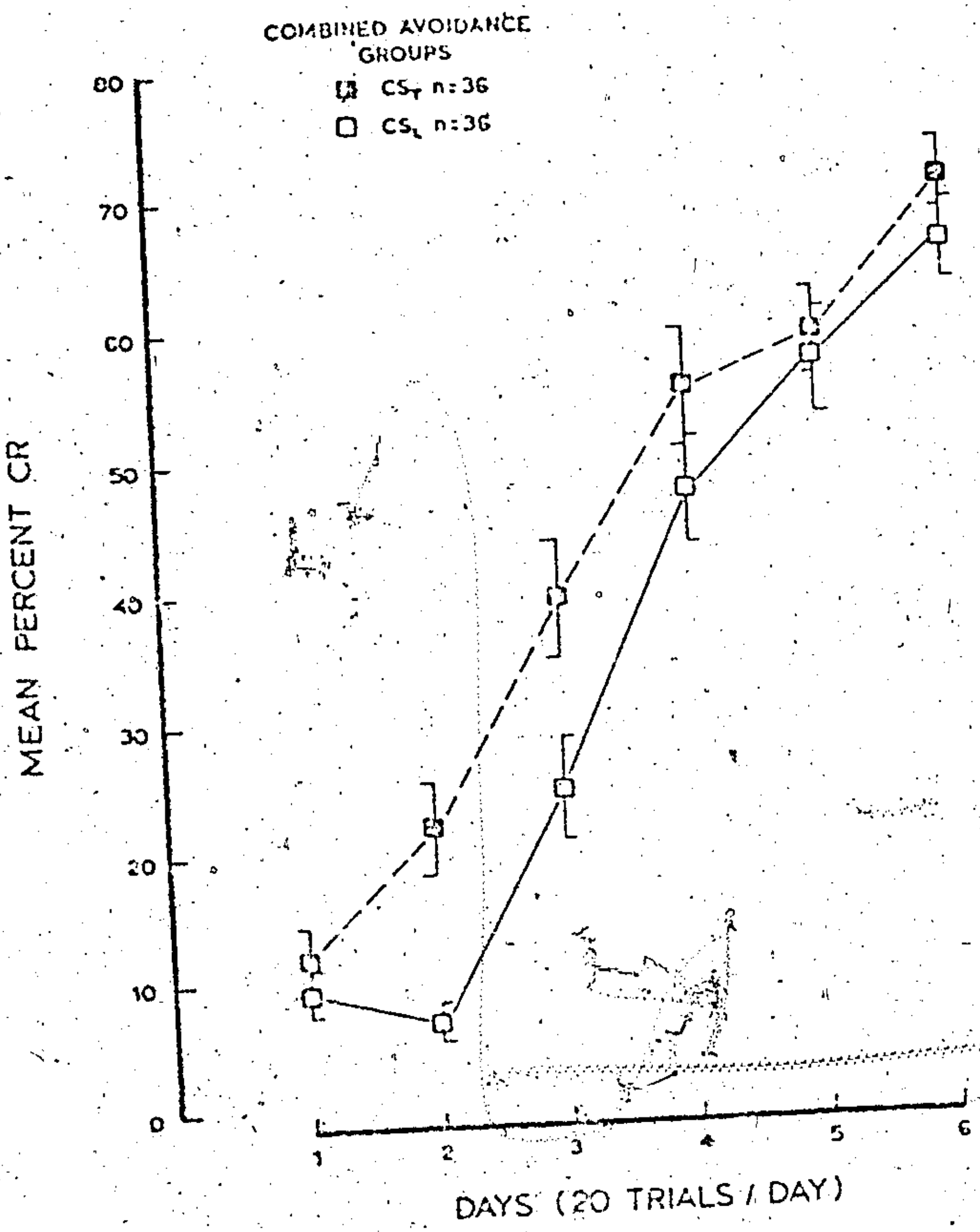

COMBINED AVOIDANCE GROUPS
CS n:36
CS n:36
MEAN PERCENT CR
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
DAYS (20 TRIALS / DAY)

Figure 14

avoidance condition, and of these, the numbers that evidenced more, and fewer, CRs in their yoked condition than in their avoidance condition are presented in Appendix A. A summarized version of the data in Appendix A is presented in Table 9.

TABLE 9

The Numbers of Reciprocally-Yoked Subjects That Received More, and Fewer, Shocks in Their Yoked Condition that in Their Avoidance Condition, and of These, the Numbers That Evidenced More, and Fewer CRs in Their Yoked Condition than in Their Avoidance Condition

23 received more shocks	7 evidenced more CRs 16 evidenced fewer CRs
23 received fewer shocks	22 evidenced fewer CRs 1 evidenced more CRs
2 received same number of shocks	1 evidenced more CRs 1 evidenced fewer CRs

Table 9 shows that 1) 7 of the 23 subjects that received more shocks in their yoked condition evidenced more CRs, and the other 16 evidenced fewer CRs, in that condition than in their avoidance condition, 2) 22 of the 23 subjects that received fewer shocks in their yoked condition evidenced fewer CRs in that condition than in their avoidance condition, and 3) in the pair of subjects that received the same number of shocks in both conditions, one evidenced more, and the other evidenced fewer, CRs in its yoked condition than in its avoidance condition.

Self-Yoking. The mean percent CR scores for the six days of conditioning in Phases I and II for the four Avoidance-Avoidance-Control groups are presented in Figure 15. Figure 15 shows that those groups that were shifted from tone to light (i.e., Sets 1 and 2) evidenced very similar amounts of conditioned responding in the two phases, while those that were shifted from light to tone (i.e., Sets 3 and 4) evidenced more CRs in Phase II than in Phase I. The numbers of subjects that evidenced more, and fewer, CRs in Phase II than in Phase I in each of these groups are presented in Table 10.

TABLE 10

The Numbers of Avoidance-Avoidance-Control Subjects, in Each Set, That Evidenced More, and Fewer, CRs in Phase II than in Phase I.

Set	Phase I	Phase II	More	Fewer	Same
1	CS_T-US_L	CS_L-US_R	3	3	0
2	CS_T-US_R	CS_L-US_L	3	3	0
3	CS_L-US_L	CS_T-US_R	5	1	0
4	CS_L-US_R	CS_T-US_L	5	1	0

Table 10 shows that, in those groups that were shifted from tone to light, the number of Avoidance-Avoidance-Control subjects that evidenced more CRs in Phase II than in Phase I equalled the number that evidenced fewer CRs in Phase II than in Phase I, whereas in those groups that were shifted from light to tone, a large majority of the subjects evidenced more CRs in Phase II than in Phase I. Thus, the results of these within-subject, between-phase comparisons paralleled those of the Avoidance I-

Figure 15

Experiment 3: The mean percent CR scores for the six days of conditioning in Phases I and II for the subjects (Avoidance-Avoidance-Control) in each set that received avoidance conditioning in both phases.

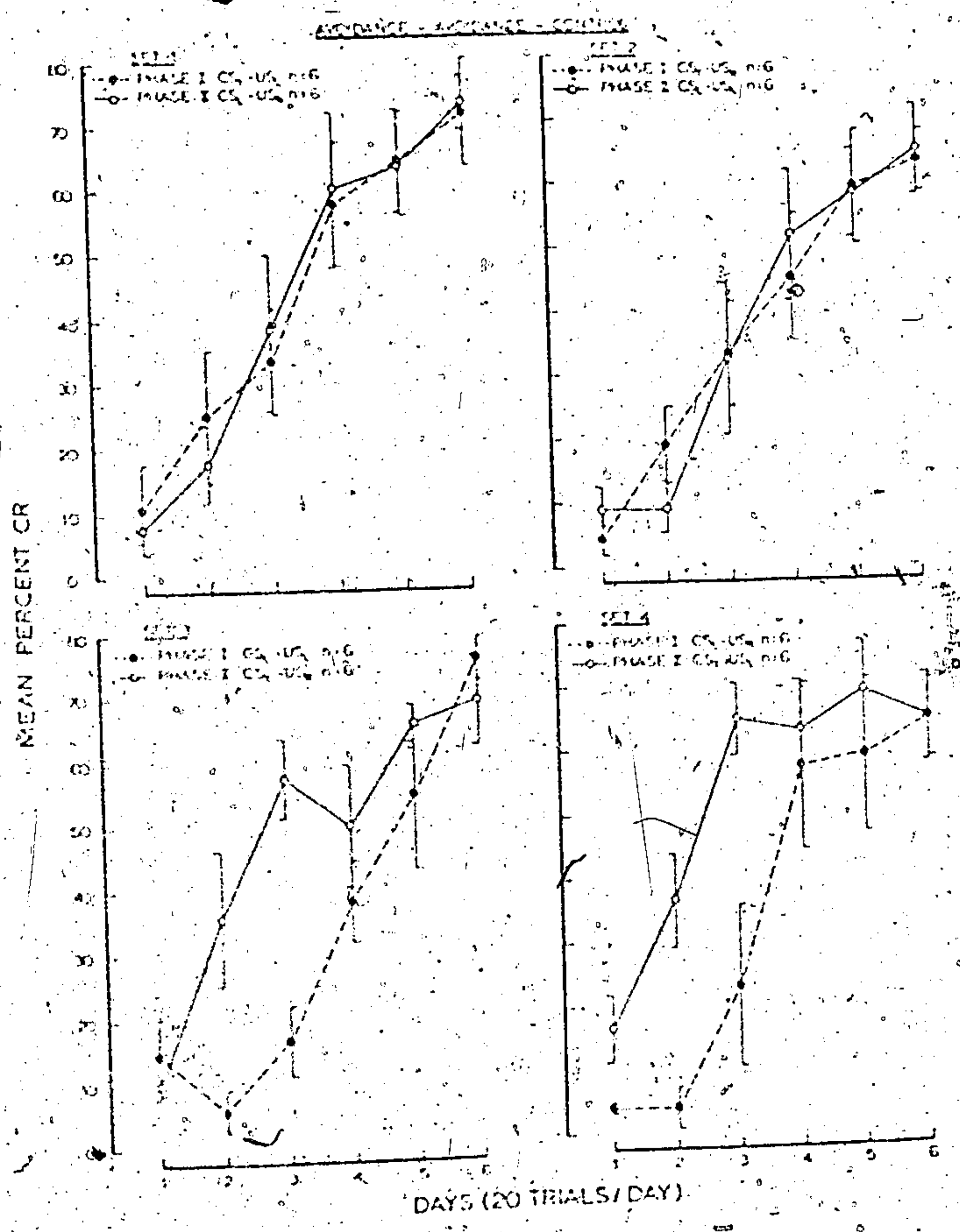


Figure 15

Avoidance II, between-subject comparisons in the corresponding sets of reciprocally-yoked pairs (see Table 8).

The numbers of Self-Yoked subjects that evidenced more, and fewer, CRs in their yoked condition than in their avoidance condition are presented in Table 11.

TABLE 11

The Numbers of Self-Yoked Subjects, in Each Set, That Evidenced More, and Fewer, CRs in Their Yoked Condition than in Their Avoidance Condition.

Set	Phase I	Phase II	More	Fewer	Same
1	CS_T-US_L	CS_L-US_R	3	3	0
2	CS_T-US_R	CS_L-US_L	3	3	0
3	CS_L-US_L	CS_T-US_R	5	0	1
4	CS_L-US_R	CS_T-US_L	5	1	0

Table 11 shows that, in each set, the numbers of Self-Yoked subjects that evidenced more, and fewer, CRs in their yoked condition than in their avoidance condition corresponded closely to the numbers of Avoidance-Avoidance-Control subjects that evidenced more, and fewer, CRs in Phase II than in Phase I (see Table 10).

Despite this match between the Self-Yoked and Avoidance-Avoidance-Control groups in the numbers of subjects that evidenced more, and fewer, CRs in Phase II than in Phase I, there were differences between these groups in the actual amounts of conditioned responding. Figure 16 presents the mean percent CR scores for the six days of conditioning in Phases I and II for the four Self-Yoked groups. While the CR curves for the two phases in the Avoidance-Avoidance-Control groups in Sets 1 and 2 were almost congruent (see Figure 15), Figure 16 shows that the CR curves for the two phases were not congruent in the Self-Yoked groups in these sets. Figure 16 also shows that the separations between the CR curves for the two phases in the Self-Yoked groups in Sets 3 and 4 were greater than the separations between the CR curves for the two phases in the Avoidance-Avoidance-Control groups in these sets (see Figure 15).

Examination of the individual data revealed that the between-phase differences in the numbers of CRs for the Self-Yoked subjects that evidenced fewer CRs in Phase II than in Phase I were greater than the between-phase differences in the numbers of CRs for the Avoidance-Avoidance-Control subjects that evidenced fewer CRs in Phase II than in Phase I. Similarly, the between-phase differences in the numbers of CRs for the Self-Yoked subjects that evidenced more CRs in Phase II than in Phase I were greater than the between-phase differences in the numbers of CRs for the Avoidance-Avoidance-Control subjects that evidenced more CRs in Phase II than in Phase I. Accordingly, when the absolute between-phase difference in numbers of CRs was computed for each subject, a pair-wise comparison on this measure indicated a significant difference between the two groups ($U=144$, $Z=2.97$, $p < .01$).

Figure 16

Experiment 3: The mean percent CR scores for the six days of conditioning in Phases I and II for the subjects (Self-Yoked) in each set that received, in their yoked condition in Phase II, the protocol of shocks that they had generated under the avoidance contingency in Phase I.

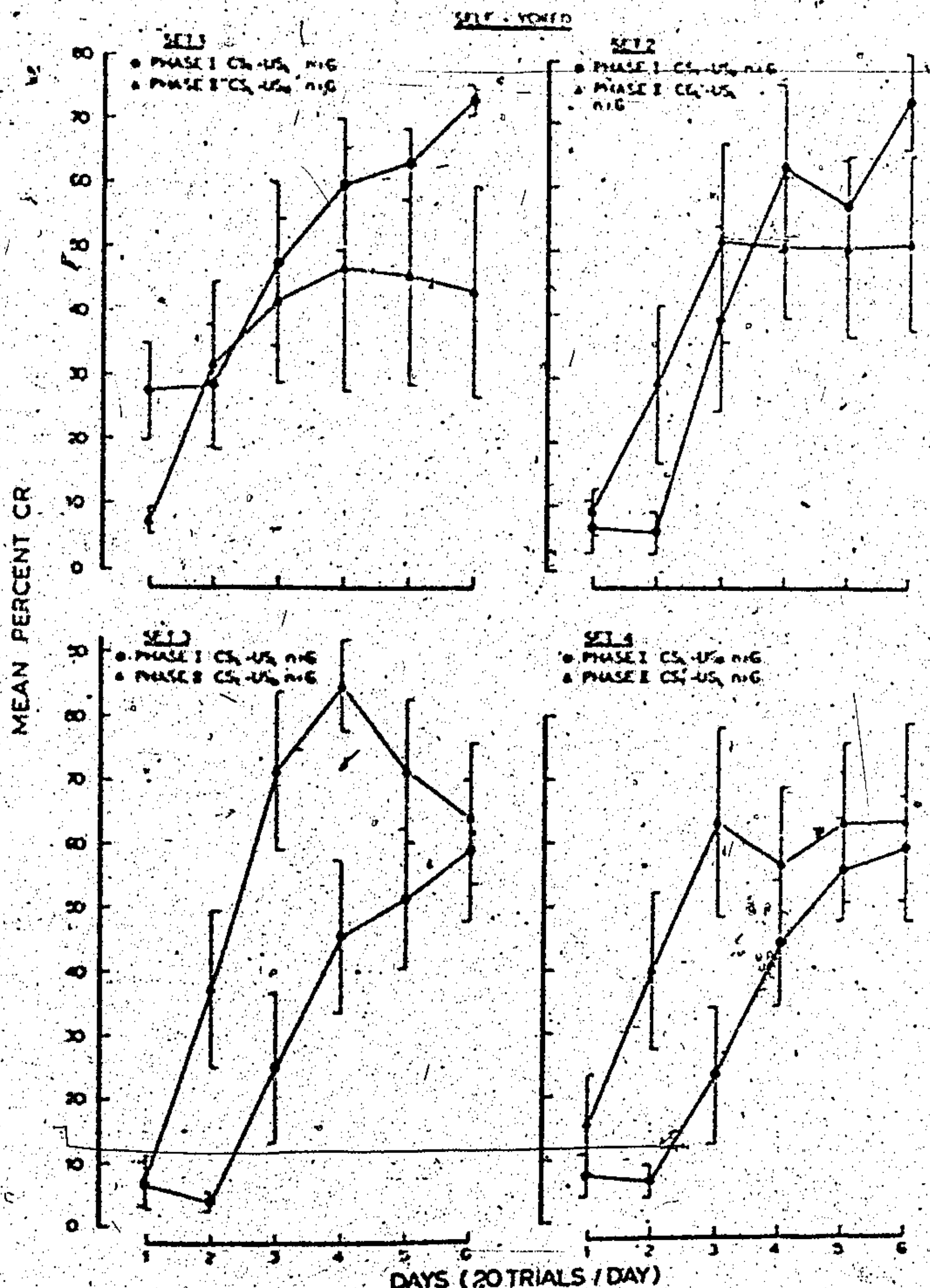

SELF - YOKED
SET 1
SET 2
SET 3
SET 4
MEAN PERCENT CR
DAYS (20 TRIALS / DAY)

Figure 16

Mimicking analysis. Because the Self-Yoked subjects received the same number, and pattern, of shocks in the avoidance and yoked phases, one might have expected a similar number, and pattern, of CRs in the two phases, with the result that an avoidance contingency would have inadvertently obtained in the yoked condition. However, as the analysis above indicates, the Self-Yoked subjects tended not to evidence similar numbers of CRs in the two phases. Nevertheless, in order to determine whether the pattern of CRs in the yoked condition mimicked the pattern of CRs in the avoidance condition, a contingency coefficient of the CRs on the 120 trials in the two phases was computed for each subject.

Following the rationale elaborated earlier in conjunction with the matched pairs in Experiment 1 (see Chapter 2, pp. 41-42), contingency coefficient values were also computed with the CR pattern for the yoked phase displaced by 1 and 2 trials in both directions relative to that for the avoidance phase. Figures 17, 18, 19 and 20 present the contingency coefficient values at the five placements for each subject in the four Self-Yoked groups. These figures show that there was little tendency for the coefficient curves to peak at the center. In fact, only 5 of the 24 subjects recorded their highest coefficient value at the 0 placement; such an outcome would be expected by chance.

Discussion

The three predictions that the present experiment was intended to test were: 1) a subject that received more shocks in its yoked condition than in its avoidance condition would evidence more CRs in the former than

Figure 17

Experiment 3: The contingency coefficient values computed on the actual CR outcomes, and with the CR pattern for the yoked phase displaced by 1 and 2 trials in both directions relative to the CR pattern for the avoidance phase, for the Self-Yoked subjects (n=6) in Set 1.

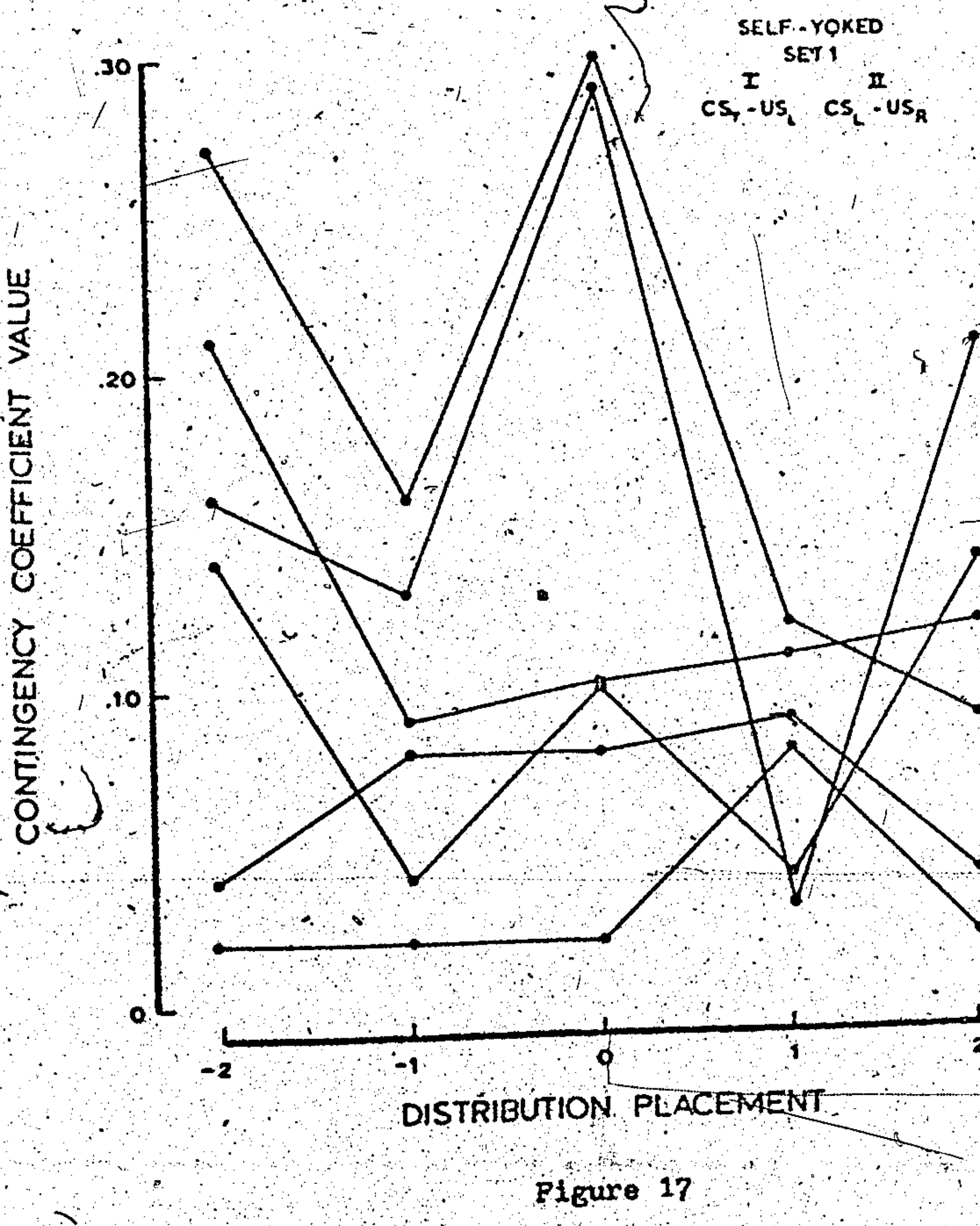

SELF - YOKED
SET 1
I
II
$CS_r - US_L$
$CS_L - US_R$
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 17

Figure 18

Experiment 3: The contingency coefficient values computed on the actual CR outcomes, and with the CR pattern for the yoked phase displaced by 1 and 2 trials in both directions relative to the CR pattern for the avoidance phase, for the Self-Yoked subjects (n=6) in Set 2.

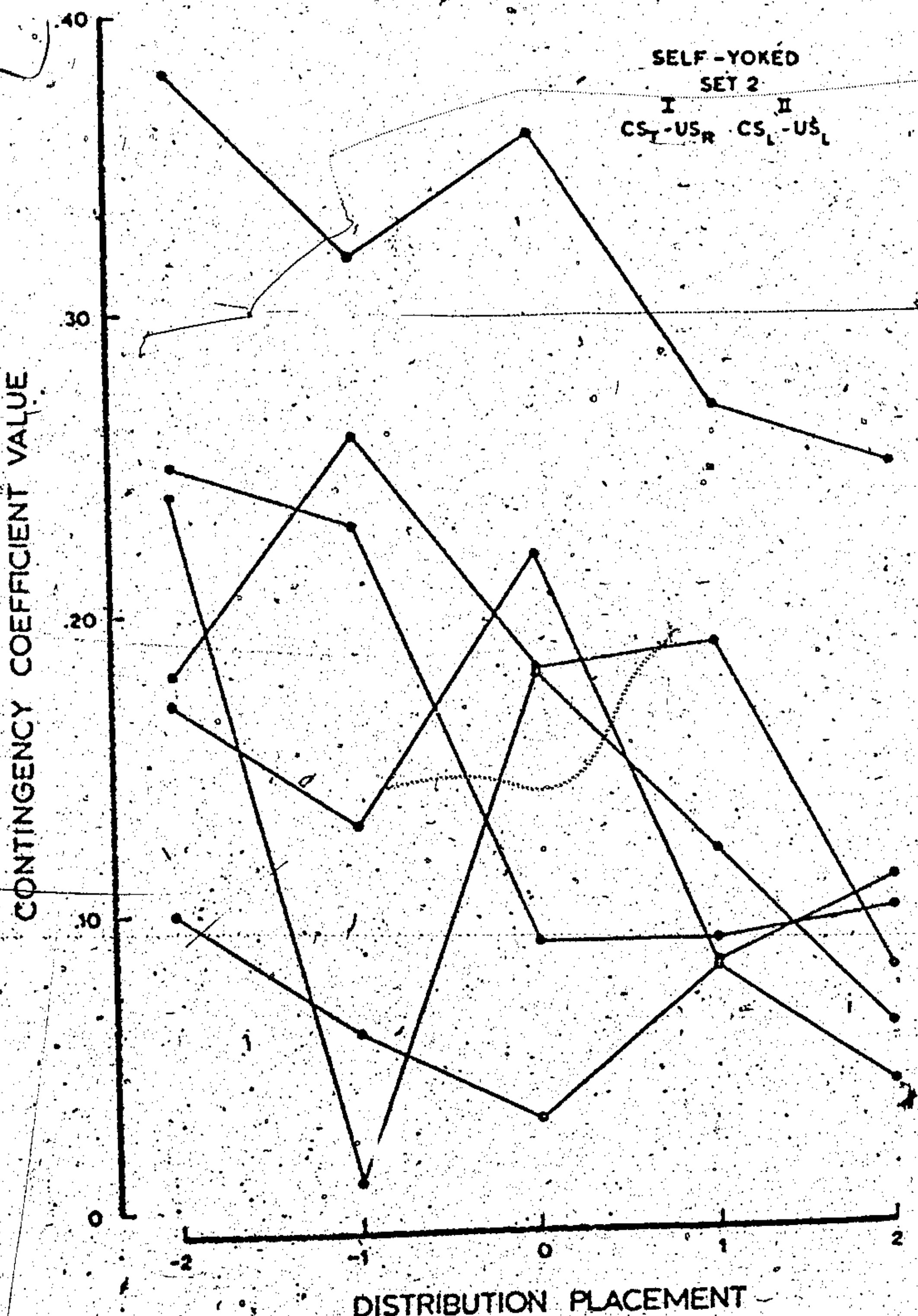

SELF-YOKED
SET 2
I II
$CS_T - US_R$ $CS_L - US_L$
CONTINGENCY COEFFICIENT VALUE
.40
.30
.20
.10
0
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 18

Figure 19

Experiment 3: The contingency coefficient values computed on the actual CR outcomes, and with the CR pattern for the yo d phase displaced by 1 and 2 trials in both directions relative to the CR pattern for the avoidance phase, for the Self-Yoked subjects (n=6) in Set 3.

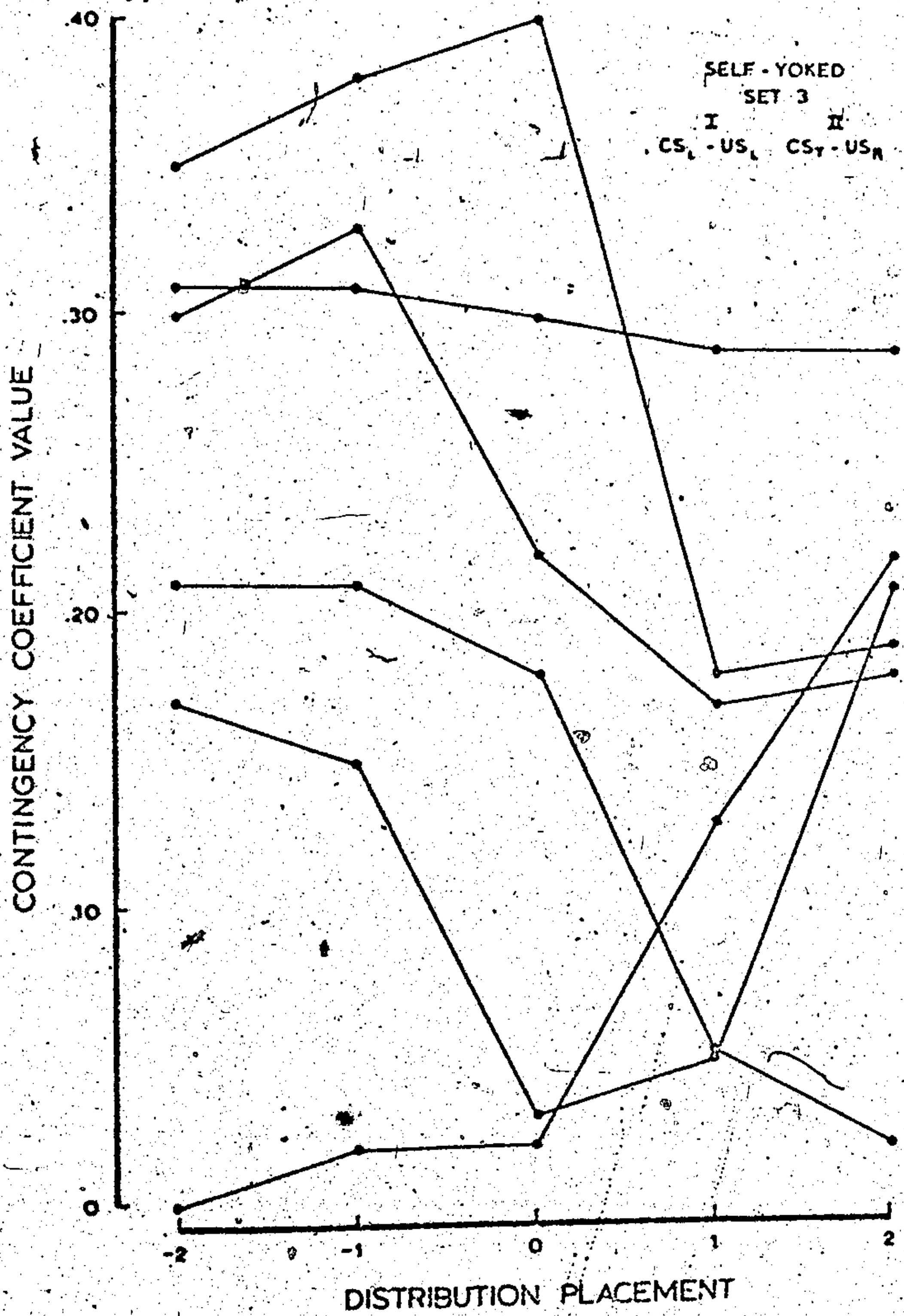

SELF - YOKED
SET 3
I
II
$CS_L - US_L$
$CS_T - US_R$
.40
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 19

Figure 20

Experiment 3: The contingency coefficient values computed on the actual CR outcomes, and with the CR pattern for the yoked phase displaced by 1 and 2 trials in both directions relative to the CR pattern for the avoidance phase, for the Self-Yoked subjects (n=6) in Set 4.

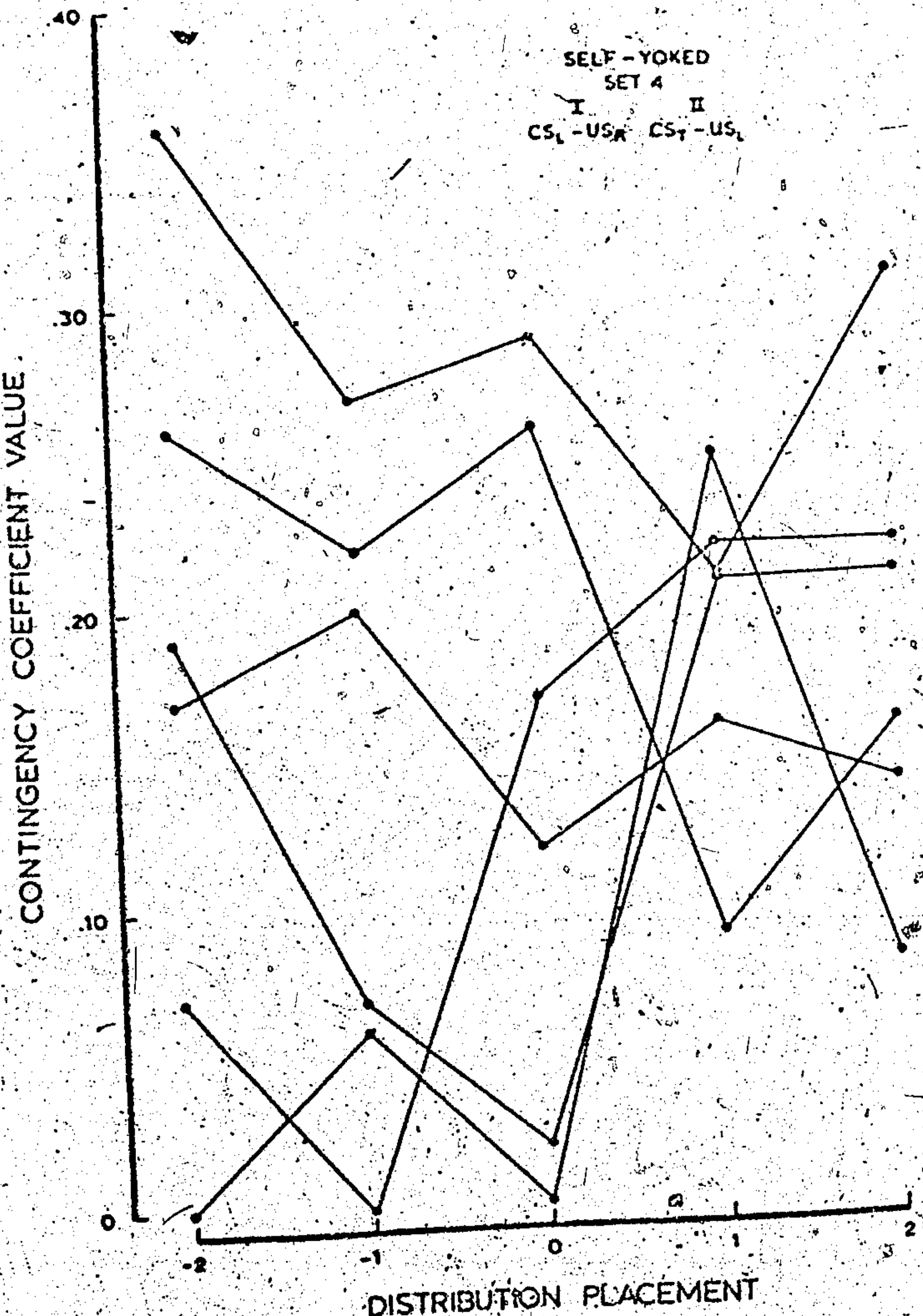

SELF - YOKED
SET 4
I
II
$CS_L - US_R$
$CS_T - US_L$
.40
.30
.20
.10
0
CONTINGENCY COEFFICIENT VALUE
-2
-1
0
1
2
DISTRIBUTION PLACEMENT

Figure 20

in the latter, 2) a subject that received fewer shocks in its yoked condition than in its avoidance condition would evidence fewer CRs in the former than in the latter, and 3) a subject that received the same number and pattern of shocks in its yoked condition as in its avoidance condition would evidence comparable amounts of conditioned responding in the two conditions. However, an implicit assumption underlying all three predictions was that things other than the contingency, and, in the case of the first two predictions, the number of shocks, would be equal in the two conditions, and this assumption did not hold in this study. Indeed, there was evidence for small, but persistent, transfer and CS effects, and an interpretation of the major findings of this experiment must take these effects into account.

The first major finding was that only 7 of the 23 subjects that received more shocks in their yoked condition than in their avoidance condition evidenced more CRs in the former than in the latter. Hence, the prediction that receiving more shocks in the yoked condition would lead to greater conditioned responding in that condition was not supported. However, because of the transfer and CS effects, these subjects received their yoked conditioning more often under the less favorable phase (i.e., Phase I), and CS (i.e., light), conditions. In fact, 14 of these 23 subjects received their yoked conditioning in Phase 1, and 15 of the 23 received it with the light (see Appendix A). Furthermore, 12 of the 16 subjects that received more shocks in their yoked condition than in their avoidance condition but failed to evidence more CRs in the former than in the latter received their yoked conditioning in Phase I. Thus, one could argue that, although these subjects received more shocks in their yoked condition than in their avoidance condition, they did not receive more shocks than they would have received under an avoidance contingency in that phase. Also, 11 of these 16 subjects received their yoked conditioning with the light, and in these cases, one could argue that they received fewer shocks than they would have received under an avoidance contingency with that CS.

If one were to extend the argument to the data for the subjects that received fewer shocks in their yoked condition than in their avoidance condition, one would expect a large number of these subjects to evidence more CRs in their yoked condition than in their avoidance condition. However, although 14 of these 23 subjects received their yoked conditioning in Phase II, and 15 of the 23 received it with the tone, only 1 of these 23 subjects evidenced more CRs in its yoked condition than in its avoidance condition. In short, the subjects that received fewer shocks in their yoked condition than in their avoidance condition evidenced fewer CRs in the former than in the latter, even those that received their yoked condition under generally more favorable phase and CS conditions. This finding is inconsistent with the argument that the failure of the 16 subjects (i.e., those that received more shocks in their yoked condition than in their avoidance condition) to evidence more CRs in their yoked condition than in their avoidance condition was due to their receiving their yoked condition under less favorable phase and CS conditions. It appears, then, that the finding that only 7 of the 23 subjects that received more shocks in their yoked condition than in their avoidance condition evidenced more CRs in the former than in the latter cannot be fully explained by the transfer and CS effects.

An alternative explanation of this unexpected finding is suggested by the results of the self-yoking part of this study. These results showed that the numbers of Self-Yoked subjects that evidenced more, and fewer, CRs in their yoked condition than in their avoidance condition matched the numbers of subjects in the corresponding Avoidance-Avoidance-Control groups that evidenced more, and fewer, CRs in Phase II than in Phase I. Hence, although 1) a majority of the reciprocally-yoked subjects that received more shocks in their yoked condition than in their avoidance condition evidenced <u>fewer</u> CRs in the former than in the latter, and 2) the reciprocally-yoked subjects that received fewer shocks in their yoked condition than in their avoidance condition evidenced fewer CRs in the former than in the latter; 3) the numbers of Self-Yoked subjects (that received the same number and pattern of shocks in both conditions) that evidenced more, and fewer, CRs in their yoked condition (Phase II) than in their avoidance condition (Phase I) matched the numbers of subjects in a control group (that received avoidance conditioning in both phases) that evidenced more, and fewer, CRs in Phase II than in Phase I. This set of findings indicates that a subject's performance in the yoked condition was not only determined by the number of shocks that it received, but also by the pattern of shocks. Accordingly, the failure of those 16 subjects that received more shocks in their yoked condition than in their avoidance condition to evidence more CRs in their yoked condition than in their avoidance condition may have been due to their receiving a pattern of shocks in the yoked condition that was different from the pattern that they would have generated for themselves if they had been under the avoidance contingency.

Although a Self-Yoked subject's performance in the yoked condition was importantly influenced by its receiving the same pattern of shocks in that condition as it had generated in the avoidance condition, these subjects did not evidence similar patterns of conditioned responding in the two conditions. If they had, the effect of receiving a self-generated schedule of shocks in the yoked condition could have been attributed to an inadvertent avoidance contingency. It is not clear, then, why a self-generated schedule of shocks was more efficacious than a pattern of shocks generated by a partner. In any case, additional self-yoking experiments in which the pattern of shocks would be systematically varied in the yoked condition (while holding the number constant) are required to establish the limits of influence of this variable. Nevertheless, the finding that the pattern of shocks was an important variable influencing a subject's performance in the yoked condition in this experiment indicates the inadequacy of a conditioning model (see Chapter I, p. 10) that considers only the number of shocks that a subject requires to acquire the CR, and brings into focus the extinction effects on the CR of those trials on which shock is not delivered.

The results of the between-subject, avoidance-yoked contrasts in the reciprocally-yoked pairs provided an additional unexpected finding in this study. These results showed that there tended to be fewer Type 1 yoked subjects (that acquired the CR before their avoidance partners) than Type 2 yoked subjects (that acquired the CR after their avoidance partners), indicating that some yoked subjects that were more effective than their avoidance partners failed to evidence faster acquisition than their avoidance partners. That is, some yoked subjects that received more shocks than they would have received if they had been under the avoidance contingency failed to evidence faster acquisition than their less effective avoidance partners. These failures, like those revealed in the within-subject contrasts, may have been due to these subjects' receiving a pattern of shocks that was not self-generated.

The finding that there tended to be fewer Type 1 than Type 2 yoked subjects in the reciprocal pairs in the present experiment must be reconciled with the finding that there were about equal numbers of the two types of yoked subjects in random pairs in Experiment 1. Indeed, why was the pattern of shocks an important variable influencing a subject's performance in the present experiment but apparently not an important variable influencing a subject's performance in the yoked condition in Experiment 1? An obvious place to look for an answer to this question is in the methodological differences between the two experiments. Only the tone CS was used in Experiment 1, while both the tone and offset of the houselight (to which conditioning proceeded a little more slowly than to the tone) were used in Experiment 3. Also, the US intensity was set at 5 mA in Experiment 1 and at 2 mA in Experiment 3.

Therefore, conditioning proceeded generally more slowly in Experiment 3 than in Experiment 1. Let us examine, then, how the pattern variable could have interacted with conditioning rate.

Prior to the first CR by an avoidance subject, its yoked partner receives the shock on every trial. When the avoidance subject evidences its' first CR, the shock is omitted on that trial, and a partial shock schedule begins for the yoked subject. Hence, the pattern of intermittent shocks begins at that point. Accordingly, the critical period in which the pattern variable could influence a yoked subject's acquisition performance relative to that of its avoidance partner is the period between the trial on which the avoidance subject evidences its first CR and the trial on which the avoidance subject reaches the acquisition criterion. For the avoidance subjects in Experi-ment 1, the criterion run (i.e., eight CRs in a block of 10 trials) tended to come soon after the first CR. For the avoidance subjects in the reciprocal pairs in the present experiment, there tended to be many trials interpolated between the first CR and the criterion run. In-deed, the difference between these two groups in the number of trials between the first CR and the criterion run was significant (U=42.5, Z=2.65, p < .01). Hence, the pattern of shocks may have been an im-portant variable influencing the performance of the yoked subjects in the present experiment (and not in Experiment 1) because the critical period of shock pattern was protracted in the present experiment.

CHAPTER 5

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Summary

The purpose of the research described in the last three chapters was to obtain experimental evidence that would bear on the argument that bias arising from within-pair mismatching in effectiveness contributes to the avoidance-yoked difference obtained in eyelid conditioning. The logic of Experiment 1 was straightforward: If within-pair mismatching in effectiveness does contribute to the avoidance-yoked difference, then eliminating the mismatches should reduce the difference. The strategy that was implemented in Experiment 1 was also straightforward: Match pairs of subjects for effectiveness on the basis of their performance in a preliminary conditioning phase, and compare the results of avoidance-yoked conditioning in such matched pairs with those in pairs that are formed by random assignment; if the avoidance-yoked difference were smaller in matched than in random pairs, support for the bias argument would be provided.

The results of Experiment 1 indicated that the avoidance-yoked difference in asymptotic performance was smaller in the matched groups than in the random group. However, the avoidance-yoked difference may have been smaller in the matched groups because most of the subjects in these groups, unlike those in the random group, had reached a high CR level <u>before</u> they entered the avoidance-yoked phase. Therefore, although this finding of a reduced avoidance-yoked difference in matched pairs was consistent with the bias argument, it did not provide unequivocal support for it.

A more interesting finding in Experiment 1 was that there were two types of yoked subjects in the random pairs. One type of yoked subject, labeled Type 1, evidenced faster acquisition than its avoidance partner and tended to reach a highest CR score for a single day that was higher than that reached by its avoidance partner. The other type of yoked subject, labeled Type 2, evidenced slower acquisition than its avoidance partner and tended to reach a highest CR score for a single day that was lower than that reached by its avoidance partner. For two reasons, it was suggested that these Type 1 and Type 2 yoked subjects might represent yoked subjects that were more effective, and less effective, respectively, than their avoidance partners. The first reason was that the performances that characterized the Type 1, and Type 2, subjects were consistent with the performances that would be expected from yoked subjects that were more effective, and less effective, than their avoidance partners. The second reason was that the proportions of each type of yoked subject were about the same, and in random pairs, one would expect that the number of pairs in which the yoked subject was more effective than its avoidance partner would equal the number of pairs in which the yoked subject was less effective than its avoidance partner.

Additional support for the notion that Type 1, and Type 2, yoked subjects represented those yoked subjects that were more effective and

and less effective, respectively, than their avoidance partners was provided by the results of Experiment 2. In this experiment, a group of yoked subjects was given the protocol of shocks that had been generated by one of the nine avoidance subjects in the random pairs in Experiment 1. The conditioning effectiveness of this selected avoidance subject could be estimated from its rate of acquisition relative to the rates of acquisition of the other subjects in the avoidance group. The results indicated that the proportions of Type 1, and Type 2, yoked subjects corresponded well to the proportions of more effective, and less effective, yoked partners that would be expected on the basis of the avoidance subject's estimated conditioning effectiveness.

In Experiment 3, there were some changes made in the conditioning stimuli. Two CSs were required for the reciprocal yoking procedure. So, in addition to the tone CS that had been used in Experiments 1 and 2, light offset was used as a CS in Experiment 3. Also, in addition to the shock to the left eye that had been used as the US in the first two experiments, shock to the right eye was used as a US in Experiment 3. Finally, the US intensity was reduced from 5 mA to 2 mA.

The reciprocal yoking procedure was used in Experiment 3 to provide two kinds of within-subject, avoidance-yoked contrasts. In one kind of contrast, a reciprocally-yoked subject received more shocks during acquisition in its yoked condition than in its avoidance condition. In the other kind of contrast, a reciprocally-yoked subject received fewer shocks during acquisition in its yoked condition than in its avoidance condition. The logic of Experiment 3 was the following: If a subject's performance in the yoked condition were a direct function of whether it received more or fewer shocks than it would have received if it had been under the avoidance contingency, then 1) a subject that received more shocks in its yoked condition than in its avoidance condition would evidence more CRs in the former than in the latter, and 2) a subject that received fewer shocks in its yoked condition than in its avoidance condition would evidence fewer CRs in the former than in the latter.

This logic was extended to include the following: If a subject received the same number of shocks in its yoked condition as in its avoidance condition, it would evidence comparable amounts of conditioned responding in the two conditions. In order to obtain a within-subject contrast in which the number of shocks in the avoidance and yoked conditions were the same, the self-yoking procedure was used. In this procedure, the protocol of shocks that was generated by a given subject under the avoidance contingency was subsequently given to it in a yoked phase. Hence, not only the number, but also the pattern, of shocks was the same in both conditions.

The results of the within-subject contrasts in Experiment 3 indicated: 1) unexpectedly, a majority of the reciprocally-yoked subjects that received more shocks in their yoked condition than in their avoidance condition evidenced *fewer* CRs in the former than in the latter, 2) the reciprocally-yoked subjects that received fewer shocks in their yoked condition than in their avoidance condition evidenced fewer CRs in the former than in the latter, and 3) although the self-yoked subjects did not evidence comparable amounts of conditioned responding in the two phases, the numbers of these subjects that evidenced more, and fewer, CRs in their yoked condition (Phase II) than in their avoidance condition (Phase I) matched the numbers of subjects in a control group (that received avoidance conditioning in both phases) that evidenced more, and fewer, CRs in Phase II than in Phase I. The conclusion that was drawn from this set of findings was that the pattern, as well as the number, of shocks was an important factor determining a subject's performance in the yoked condition, and the explanation that was given for the unexpected first finding was that, although these subjects received more shocks in their yoked condition than in their avoidance condition, they received their shocks in the yoked condition in a pattern that was not suited to them.

It was suggested that the pattern variable might also account for the unexpected results of the between-subject, avoidance-yoked contrasts in the reciprocal pairs. These results indicated that there tended to be fewer Type 1 than Type 2 yoked subjects in these random pairs, i.e., that some yoked subjects that received more shocks than they would have received if they had been under the avoidance contingency failed to evidence faster acquisition than their less effective avoidance partners. This finding had to be reconciled with the finding that there were about equal numbers of the two types of yoked subjects in the random pairs in Experiment 1. It was first noted that, due to the changes in the conditioning stimuli, conditioning proceeded generally more slowly in Experiment 3 than in Experiment 1. Further analyses indicated the the period between the trial on which an avoidance subject evidenced its first CR and the trial on which it reached the acquisition criterion was longer for the avoidance subjects in Experiment 3 than for those in Experiment 1. Since this period was considered to be the critical period in which the pattern variable could have influenced a yoked subject's acquisition performance relative to that of its avoidance partner, it was suggested that the pattern variable exerted its influence in Experiment 3, and not in Experiment 1, because this period was protracted in Experiment 3 due to the slower conditioning rate in that experiment.

Conclusions

The research described in this paper began as an attempt to directly test Church's (1964) bias argument in the rabbit eyelid conditioning preparation. The notion at the outset was that bias was an effect that spuriously inflated instrumental-yoked differences in the direction of instrumental superiority (cf, Kimmel & Sternthal, 1967); and Experiment 1 was designed to separate any bias effect from the effect of the avoidance contingency in this preparation. However, the attempt to separate these two effects in Experiment 1 with a pre-yoke matching procedure was unsuccessful. Nevertheless, the results of Experiment 1 did provide indirect evidence to support the bias argument, and additional supporting evidence was provided by the results of Experiments 2 and 3. That is, the results of the between-subject, and within-subject, avoidance-yoked contrasts in these experiments supported the conceptualization of a yoked subject as one that receives more, or fewer, shocks, and in a different pattern, than it would if delivery of shocks were contingent upon its own behavior. The first conclusion, then, is that differences in acquisition performance between avoidance and yoked subjects in the rabbit eyelid conditioning preparation are the result of bias.

Since the observed differences in acquisition performance between the avoidance and yoked subjects in these experiments were consistent with the bias argument, one could maintain that there was no effect of the avoidance contingency per se on acquisition. Indeed, avoidance conditioning in this preparation could be viewed as a case of classical conditioning - a special case because of its particular allocation of USs. However, the results of Experiments 1 and 2 indicated that the avoidance contingency did contribute to the maintenance of the CR. This finding is consistent with the "need" argument that was formulated by Moore and Gormezano (1961) to account for their original finding of an avoidance-yoked eyelid conditioning difference: "The superior performance of Ss in the instrumental procedure appears to be due then, to their receiving the UCS when needed, i.e., when the CR fails to occur whereas, no such consistent relationship exists for the classical partial reinforcement procedure (p. 558)." And, in a more formal statement:

> "If one were to assume that the reinforcing effect of the UCS is some inverse function of

> the strength of association between the CS and the CR or varies with S's presumed conditioning state (Bower & Theois, 1964), then presentation of the UCS would have a maximum effect on response probability when the CR fails to occur and a small or no effect when the CR does occur. Since in the yoked-classical procedure any number of trials may occur in which neither the CR and UCS occur, it would be expected that for an equal number of UCS presentations these contingencies would lead to inferior performance (Gormezano, 1965, p. 57)."

Presumably, the impact of this argument would be greatest during maintenance when shocks occur most infrequently (cf. Hupka, Massaro & Moore, 1968). The second conclusion, then, is that the finding that subjects under the avoidance contingency evidenced better maintenance of the CR than subjects in the yoked condition is consistent with Gormezano's "need" argument.

Implications

Since the results of the eyelid conditioning experiments described in the last three chapters provided support for the bias argument, these results contrast with the results of earlier studies (Terrant, 1968; Maier, Anderson & Lieberman, 1972) in which the bias argument did not receive experimental support. However, there were several methodological differences between these studies and the experiments presented here. These methodological differences could account for the differences in results, and might also afford clues concerning the prevailing conditions under which bias is most likely to be present in instrumental-yoked comparisons.

Terrant (1968) found that ineffective avoidance subjects in human GSR conditioning failed to show an increase in the magnitude of their CRs over trials. That is, the CS-US pairings that these subjects continued to receive did not produce an increase in the dependent measure of learning in his study. Clearly, the bias cannot operate in a conditioning preparation in which the designated instrumental response does not increase as a function of the number of CS-US pairings. In contrast to the relationship between CR amplitude and the number of CS-US pairings in the GSR conditioning preparation, anticipatory closures in eyelid conditioning do increase as a function of the number of CS-US pairings. A possible explanation for this disparity is that eyelid conditioning involves the innervation of skeletal muscle, while GSR conditioning involves the innervation of smooth muscle. In this regard, Terrant (1968) proposed a distinction between discrete dependent variables (e.g., eyelid closure) and continuous dependent variables (e.g., GSR), and suggested that the bias argument may be more applicable to the former than to the latter. The results of the experiments described here are in agreement with this suggestion.

In their first experiment, Maier, Anderson and Lieberman (1972) found that a group of rats that could escape shock in a wheel-turn chamber in the first phase showed significantly more shock-elicited aggression in a fighting chamber in a subsequent phase than did their yoked partners that received the same amount of inescapable shock in the first phase. In their second experiment (see Chapter 1, p. 17), these investigators sought to test the bias argument in their paradigm. However, the application of the bias argument is complicated in this case because their paradigm involves two separate phases. Before one can determine how mismatching might give rise to bias, one must specify the relationship between the effects of shock in the wheel-turn chamber in the first phase and the aggression response to shock in the fighting chamber in the second phase. What this relationship is, is not obvious, and, in their rendition of the argument, Maier et al. do not state explicitly what they assumed it to be. On the other hand, in the eyelid conditioning preparation, the assumed relationship between the US and the designated avoidance response is obvious; indeed, one can reasonably assume that the avoidance response is a direct result of the CS-US pairings. This difference between these two preparations in the directness of the assumed relationship between the event and the response may account for the disparity in the results.

These comparisons between the results of the eyelid conditioning experiments presented here and the results of earlier experiments that examined the bias argument in other preparations suggest that bias is most likely to be present in instrumental-yoked comparisons where it can be reasonably assumed that the event has a clear, and reliable, effect on the designated instrumental response. Therefore, the implications of the results of the experiments presented here would be strongest for instrumental-yoked comparisons in which these conditons obtain.

Several instrumental-yoked comparisons meeting these conditions have appeared in a research program that has sought to determine whether instrumental conditioning can occur in insects. Horridge (1962) introduced the yoking procedure into this program of research. The subjects in his study were headless cockroaches and locusts with all legs except one removed. For the experimental subjects, the leg was suspended over a saline solution, and these subjects received a shock (to the leg) whenever they dropped their legs below the surface of the solution. Each experimental subject had a yoked control partner. For these subjects, the contingency between leg position and shock was not in effect; instead, a yoked subject received a shock whenever one was delivered to its experimental partner.

In the first phase of Horridge's study, pairs of subjects were given 40 to 45 min of instrumental-yoked training. In the test phase that began 10 min after the end of the training phase, the instrumental contingency was put in effect for the subjects that had been in the yoked condition in the training phase, and the instrumental contingency remained in effect for the experimental subjects. The results indicated that during the first several minutes of the test phase, the experimental subjects received significantly fewer shocks than did the subjects that had been yoked in the training phase. Horridge concluded from these results that the experimental subjects had learned an association between the position of their legs and the delivery of shock.

However, Church's (1964) bias argument could be applied to the instrumental-yoked comparison in Horridge's (1962) preparation. The argument would proceed in the following way: The shock, as Horridge noted, unconditionally elicits leg flexion in these animals. Assume that insects differ in their reactivity to shock, i.e., that some insects require fewer shocks than others to activate their motor systems sufficiently to produce leg-holding, and fewer periodic shocks thereafter to maintain this activation level. Then, random assignment to pairs would lead to some pairs in which the experimental subject is more reactive to shock than its yoked partner and other pairs in which the experimental subject is less reactive to shock than its yoked partner. Let us examine the expected results of training in each of these two cases.

In the case in which the experimental subject is more reactive than its yoked partner, the experimental subject would take a few shocks to reach the activation level required to produce leg-holding, and a few shocks periodically thereafter to maintain this level. Its yoked partner would not receive enough shocks to reach the activation level that it requires to produce leg-holding, and would therefore maintain its leg in a lowered position. In the other case, the yoked subject would reach the criterion activation level quickly; its instrumental partner would continue to receive shocks until it also reached the criterion level. Hence, at the end of 40 to 45 min of training, all the experimental subjects, but not all the yoked subjects, would be consistently holding their legs in an elevated position. This difference between the groups at the outset of the test phase could have produced the difference in performance during the early part of this phase. Eventually, the yoked subjects that had not received sufficient shocks in the first phase would reach the criterion activation level, and this could account for the failure to find a difference between the groups later in the test phase.[3]

Although Horridge (1962) did not present the acquisition data in his paper, his description of the behavior of two types of yoked subjects during training suggests that the two types of mismatched pairs were present in his study. As the following quote reveals, the behavior of these two types of subjects was very similar to the behavior of the Type 2 and Type 1 yoked subjects in the random pairs in the experiments presented here:

> "In about half the instances the R (i.e., yoked) animal moves its leg reflexly at first in response to each shock but then adapts to the stimulus and hangs limp with little movement. In other instances the leg is raised at the first few shocks [which usually come rapidly since the P (i.e., instrumental) animal is initially active] and it may then stay up for many minutes (p. 41)."

Later in this paragraph, Horridge expressed reservations about using an instrumental-yoked difference in training as evidence for learning, and suggested instead that learning be assessed in the test phase following the training phase with a 10 min retention interval. However, although conditions in this test phase were identical for both subjects

[3]Although this argument has focussed on the effect of the number of shocks on the activation level of the motor system, the pattern of shocks may also be important in this preparation.

in a pair, the differences that were observed in this phase could still have been due to the effects of the bias in the yoking procedure that was used during training.

Although Horridge's (1962) original finding has been replicated and extended by several other investigators (e.g., Eisenstein & Cohen, 1965; Pritchatt, 1968; Disterhoft, 1972), no attempt has been made to test the bias argument in this preparation. Unfortunately, the results of the experiments described here suggest that, if the bias is present, its effects could not be separated from possible effects of the instrumental contingency.

APPENDIX A

Experiment 3: The numbers of reciprocally-yoked subjects, in each set, that received more, and fewer, shocks in their yoked condition than in their avoidance condition, and of these, the numbers that evidenced more, and fewer, CRs in their yoked condition than in their avoidance condition.

Set 1 Avoidance I CS_T-US_L - Yoked II CS_L- US_R.

3 received more shocks	2 evidenced more CRs 1 evidenced fewer CRs
2 received fewer shocks	2 evidenced fewer CRs
1 received same number of shocks	1 evidenced fewer CRs

Yoked I CS_T-US_L - Avoidance II CS_L-US_R

2 received more shocks	0 evidenced more CRs 2 evidenced fewer CRs
3 received fewer shocks	3 evidenced fewer CRs
1 received same number of shocks	1 evidenced more CRs

Set 2 Avoidance I CS_T-US_R - Yoked II CS_L-US_L

3 received more shocks	1 evidenced more CRs 2 evidenced fewer CRs
3 received fewer shocks	3 evidenced fewer CRs

Yoked I CS_T-US_R - Avoidance II CS_L-US_L

3 received more shocks	1 evidenced more CRs 2 evidenced fewer CRs
3 received fewer shocks	3 evidenced fewer CRs

Set 3 Avoidance I CS_L-US_L - Yoked II CS_T-US_R

2 received more shocks	1 evidenced more CRs 1 evidenced fewer CRs
4 received fewer shocks	3 evidenced fewer CRs 1 evidenced more CRs

Yoked I CS_L-US_L - Avoidance II CS_T-US_R

4 received more shocks	0 evidenced more CRs 4 evidenced fewer CRs
2 received fewer shocks	2 evidenced fewer CRs

Set 4

Avoidance I CS_L-US_R - Yoked II CS_T-US_L

1 received more shocks	1 evidenced more CRs
5 received fewer shocks	5 evidenced fewer CRs

Yoked I CS_L-US_R - Avoidance II CS_T-US_L

5 received more shocks	1 evidenced more CRs 4 evidenced fewer CRs
1 received fewer shocks	1 evidenced fewer CRs

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