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RESPONSE-REINFORCER MANIPULATIONS
IN THE ANALYSIS
OF BLOCKING

A Thesis Presented

By

KENNETH JOHN STICKNEY

Submitted to the Graduate School of the
University of Massachusetts in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE

May 1980

Psychology

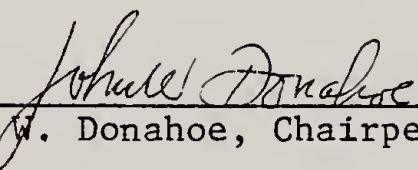
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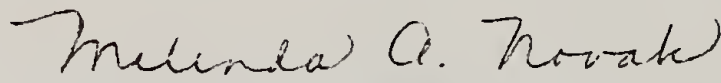
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C H A P T E R I

INTRODUCTION

The effect of prior experience on a current learning task is of the utmost relevance to theories of learning. In special cases, prior experience may even prevent subsequent learning. These cases can generally be thought of as instances of the blocking phenomenon (e.g., Kamin, 1969; Wagner, Logan, Haberlandt, and Price, 1968). Specifically, if a stimulus A is paired with a reinforcer so that a response comes under the control of that stimulus, then when a novel stimulus B is simultaneously compounded with A and also paired with the reinforcer, stimulus B does not acquire control over the response, as measured by presentation of B alone in extinction. Stimulus A is said to "block" the establishment of stimulus control by B.

The purpose of the present study was to investigate the role of the response in procedures that typically demonstrate the blocking phenomenon. Of specific interest is the effect on blocking of a change in the response elicited by the reinforcer, through manipulations of that reinforcer in the transition from single stimulus training to compound stimulus training.

The introduction to this research includes: (a) a rationale for such an investigation; (b) a review of the role of environmental events (i.e., conditioned stimuli and reinforcers) in blocking; (c) a detailed look at recent studies relevant to the role of the response of interest in procedures that produce blocking; and (d) a brief strategy for

investigating the role of the response in blocking.

Rationale

The generality of the blocking phenomenon is well-documented, and procedures that generate the result have become important testing grounds for theories of learning. The blocking result has been obtained with rats in conditioned emotional response (CER) procedures (Kamin, 1969a) and in discrete trial appetitive procedures (Neely and Wagner, 1974). It has been obtained with pigeons in discrete trial procedures (Vom Saal and Jenkins, 1970) and in free-operant successive discrimination procedures (Mackintosh and Honig, 1970). It has been demonstrated with rabbits in classical conditioning procedures (Marchant and Moore, 1973), and with goldfish in discrete-trial procedures (Tennant and Bitterman, 1975). It has also been found that control by stimulus B (often referred to as the redundant stimulus) may be blocked by a pre-trained stimulus from the same modality, or from a different modality (Seraganian, 1974). Moreover, this list by no means exhausts the various experimental paradigms that have demonstrated blocking.

These many and varied demonstrations of block provide strong evidence that temporal contiguity is insufficient for the establishment of associations among stimuli and reinforcers in a learning procedure. If temporal contiguity were sufficient for the formation of associations, then the redundant CS in the blocking paradigm should become associated with the reinforcer and thus elicit conditioned responding. The insufficiency of contiguity, by itself, is an important datum, but what re-

mains to be specified are the conditions which are sufficient for learning: more specifically, are there any conditions under which a redundant stimulus may come to control behavior? Obviously, procedures that attenuate or eliminate the blocking effect are important methods for determining the essential conditions for learning, and thus have much theoretical importance.

Stimuli, Reinforcers, and Blocking

Attempts to eliminate blocking have involved manipulations occurring in the transition from pre-training with Stimulus A (usually called Stage I) to compound stimulus training with the addition of Stimulus B (usually called Stage II). For example, various characteristics of the reinforcing event have been manipulated, such as changes in US intensity (Feldman, 1971; Kamin, 1969a; Neely and Wagner, 1974), changes in the quality of the US (Bakel, Johnson, and Rescorla, 1974), and the time of occurrence of such changes during Stage II (Mackintosh and Turner, 1971). In general, these studies suggest the following conclusions: (a) only an upward shift in US intensity will attenuate blocking (other changes in the US will not necessarily have an effect on blocking); and (b) such shifts must occur when the redundant stimulus is first introduced in Stage II.

There has also been a lively interest in the effects on blocking of novel events occurring shortly after each compound trial of Stage II. The experiments of this type have utilized three classes of manipulations: (a) brief presentations of the compound CS or its elements

(Donegan, Whitlow, and Wagner, 1977; Gray and Appignansey, 1973); (b) presentations, delays, or omissions of the US that is used as the reinforcer (Dickinson, Hall and Mackintosh, 1976; Kremer, 1979; Mackintosh, Bygrave, and Picton, 1977); and (c) presentations or omissions of a US different from that used as the paired reinforcer (Dickinson and Mackintosh, 1978). Several generalizations follow from these studies. First, the effectiveness of the post-trial event in attenuating blocking decreases as the time between the trial and the event increases, but the effect of the novel event appears to be on the succeeding rather than the preceding trial. Second, the effects of post-trial CS events on blocking depend on the "subject's pre-conditioning responsiveness to the CS" (cf. Donegan, Whitlow, and Wagner, 1977). Third, in order for post-trial US events to affect conditioning, the post-trial and on-trial US must be the same. Finally, the attenuating effects of post-trial US events do not always summate with other procedures that attenuate blocking (hereafter called "unblocking" procedures).

The above "unblocking" procedures have involved manipulations of the stimulus events involved in the acquisition process (CS, US, and contextual stimuli) and so-called non-associative stimuli as well. Thus the necessary and sufficient conditions for the formation of new associations (which are inferred from unblocking) have been assumed to be simply changes in environmental events at the time the redundant stimulus is added to the training trials. There has been little explicit study of manipulations of stimulus events that directly alter the

response that comes under the control of the stimuli in these procedures. Therefore, there is some question as to the effects on the blocking result of manipulations of stimuli that affect the response of interest in the blocking procedure. Will the behavioral control acquired by a stimulus A during the training of one response using a reinforcer transfer to a new response which is trained with the same stimulus and type of reinforcer? Furthermore, will this transfer of control prevent (or block) a new stimulus B (added in compound to the pre-trained stimulus A) from acquiring control over the response? In essence, are the conditions for blocking transferable across responses, or do changes in the response system due to changes in reinforcer locus generate opportunities for novel, added stimuli to acquire control over that response?

The Role of the Response in Blocking

Recently, there have been several studies concerned with the behaviors controlled by the stimuli of interest in procedures that are similar if not identical to the usual blocking designs. In two of these studies (Dickinson, 1977; and Goodman, 1976) manipulations of contiguity between stimulus events generated data which suggests that a change in the response under the control of the pretrained CS may indeed allow the new response to come under the control of the added CS in a blocking design.

Dickinson, in a CER blocking design, found that significant fear conditioning accrued to a tone CS during compound conditioning with a

pretrained light CS, if the pretraining of the light CS consisted of pairings with free food. It was also found that much less conditioning accrued to the tone when the pretrained light had been explicitly unpaired with free food.

In a related study, Goodman formed a compound CS with a pretrained appetitive component (A) and a novel component (B), and performed CER conditioning using that compound CS. It was demonstrated that the A component which had been previously explicitly paired with food enhanced aversive conditioning to the B component. On the other hand, the A component which had previously been unpaired with food blocked the aversive conditioning to the B component.

One can interpret the results of both experiments in the following manner. The A component that was explicitly paired in pretraining came to elicit appetitive CRs, which can be presumed to be different from the aversive response conditioned during the Stage II CER procedure. Thus, at the start of Stage II, neither component (A or B) was conditioned to the new aversive US, and neither CS could elicit the aversive response. As a consequence, the unpretrained CS would not be blocked and thus could become conditioned.

In a similar fashion, one could speculate that very different responses developed towards the A component that was explicitly unpaired with food during pretraining. Further, these responses could be more similar to those that were to be conditioned during Stage II aversive training with the compound CS. The assumption here is that an explicit "no food" event is quite similar to the explicit "shock" event, and

elicits a similar sort of response. This notion has some support, since it has been shown that animals will perform an avoidance response in order to terminate a stimulus associated with non-reinforcement (Terrace, 1971). Thus the response conditioned to the A component in explicitly unpaired pretraining with food could be so similar to the response to be conditioned during Stage II CER training that conditioning to the A component would be a priori complete. This would block conditioning to the unpretrained novel B component during Stage II conditioning.

Unfortunately, no response that might be similar to the aversive response was measured or noted during the appetitive pretraining in either study. In conclusion, these studies merely suggest that changes in the response system elicited by a pretrained stimulus will allow conditioning to accrue to a novel stimulus. Also, in these studies the role for the elicited response would seem to be independent of changes in the nature of the US, since the change in the US for both the unpaired and the paired versions of the pretrained CS was the same.

The blocking of one operant response by another has been investigated in a series of experiments by Williams (1975). In one experiment, one group of pigeons experienced the pretraining of an operant response (key peck) to a left red key, with a delay of reinforcement contingency in effect. The availability of an autoshaped green key response in the delay interval during subsequent training had no effect on the response rate for the red key for the pretrained group, but depressed red key responding in a group that did not receive the pretraining.

These results can be interpreted in the following manner. The pretraining of the delay contingency on the red key prevents (or blocks) the overshadowing of that operant response by an autoshaped response that is in a more favorable temporal relationship with the reinforcer. However, given the methods of response measurement in this study, both types of response were topographically identical; the difference between the responses is assumed only because of the experimenter-defined contingencies. Therefore, this study is more informative with respect to alleviating the effects of degrading contingencies between responses, stimuli, and reinforcers than with respect to one response blocking another.

The most relevant study regarding the role of behaviors involved in a blocking procedure is a series of experiments by Holland (1977). In his first experiment, he found that Pavlovian conditioning to a tone and a light CS using a food US conditioned a constellation of CRs that was peculiar to each CS. In his second experiment, he incorporated a blocking design to study the interaction of the groups of responses for both stimuli. It was found that CS-related and US-related aspects of the CR (conditioned response) to the added CS (B) are blocked by the pretraining of an initial CS (A). Moreover, the blocking occurs in spite of the fact that the form of the CS-related CRs to CS A is very different from the form of the CS-related CRs which occur to B during normal conditioning of B alone.

Holland concluded from this and other evidence that the form of the CR is not an important part of what is learned in the pairing of

stimuli and reinforcers; otherwise, the aspects of the CR peculiar to the added CS (B) would not have been blocked. However, there are aspects of the experiment that undermine this conclusion. The first is that the distributions of response types for the tone and the light CS overlapped greatly, as shown in Holland's first experiment. The CRs on which the two CSs differed most were those that were frequently elicited by one or the other CSs in pretraining. Thus only a fraction of the response distributions consisted of behaviors peculiar to each CS, and those were responses that were typically elicited by the relevant CS when it was presented alone. Since the particular first stage of the blocking design used in Holland's second study consisted of not only reinforced presentations of one CS, but unreinforced presentations of the other CS (to be compounded with the first in Stage II), the second CS's ability to elicit the responses peculiar to it may have been diminished prior to pairing with the reinforcer in Stage II. Alternatively, the unreinforced presentations of the second CS may be viewed as producing a latent inhibition effect, since this procedure is identical to others that have demonstrated such an effect (e.g., Lubow, Schur, and Rifkin, 1976). In either case the presence of this procedure in the first stage of Holland's blocking design may have produced the blocking result, and not the pretraining of the first CS. Thus the importance of the CR in the blocking effect is still unclear.

A Strategy of Investigation

None of the studies mentioned above combined a pure blocking de-

sign with a complete change in the response systems of interest, a manipulation necessary for studying the contribution of the response to what is learned. Hence the question remains: whether the blocking of the redundant CS is independent of manipulations of the behavior that reflects the presence or absence of such stimulus control. Specifically, if an animal learns that a CS_A signals a particular type of reinforcer which maintains a conditioned response R_1 , will the animal learn the CS_B signals the same type of reinforcer when the compound stimulus CS_{AB} is associated with that reinforcer when it is used in the conditioning of a second response R_2 ?

The purpose of the experiment that follows was to answer the preceding question, using the rabbit nictitating membrane response (NMR) conditioning preparation. In this preparation, conditioning consists of the pairing of discrete CSs with a brief shock applied to the orbital region of the eye, with the NMR measured ipsilaterally. Demonstrations of blocking using this preparation in a conventional manner have been highly successful (Marchant and Moore, 1973).

Of interest is the behavior of the nictitating membrane (NM) of the unshocked eye, and evidence that it can be treated as an independent response system. If the nictitating membranes (NMs) of both eyes can be considered independent response systems, then it is a simple matter to condition one NM only during Stage I of the blocking paradigm, and then at the start of Stage II begin to condition the opposite NM only. In this modification of the basic blocking design the temporal relationships between stimuli and reinforcers are preserved as well as

their magnitudes. The only change between stages is the change in the locus of application for the shock US, so that the opposite NMR may become conditioned.

Several rabbit studies have investigated the response contralateral to US application. Salafia, Daston, Bartosiak, Hurly, and Martino (1974) recorded from the unshocked NM of rabbits while conditioning the other membrane to a tone CS using a 2-ma shock. They found that when the shocked NM reached asymptote (about 90% CRs), the unshocked NM showed an asymptote of 30% CRs on the average. Further, the unconditioned response (UR) and CR amplitude averaged only 10-15% of those of the shocked NM. At the amplification normally used in their laboratory, most of the responses would not have reached the CR criterion of a 1 mm deflection. They therefore attributed the responses to facial tension. Even if this were incorrect, and the unshocked NM responses represented truly conditioned NMRs, there is at least a very large difference in the conditioning of responses in both NMs when only one is shocked.

In an investigation of central transfer of learning in the NMR preparation, Kettlewell, O'Connell, and Berger (1974) demonstrated in one experiment that the NM contralateral to shock US application displays few if any conditioned NMRs. In a second study they showed that previous conditioning of the NMR of one eye results in accelerated CR acquisition in the contralateral eye when the shock US is transferred to that orbital region as compared to a group not given the pretraining in the other eye. Since the control group was also not pre-exposed to

the experimental chamber for the equivalent time period, this difference in procedure may have exaggerated the difference in responding between the experimental and control groups. This bias would indicate more transfer of stimulus control than actually occurred.

The results of these rabbit NMR studies indicate that the nictitating membrane of the rabbit contralateral to the site of US application may not become conditioned. Moreover, as others have shown (e.g., Green, Breche, and Gazzaniga, 1979), interocular transfer of training is very dependent on the type of training to be transferred, and thus one cannot assume that transfer will occur in all similar but not identical procedures. To the extent that the responses elicited by the US play an important role in conditioning, one might predict that a change in the site of US application from one eye to another in the transition from Stage I to Stage II may attenuate the blocking effect. The consequence of the change in response would be revealed by conditioning to the redundant CS, as demonstrated in testing with B alone. The experiment that follows sheds some light on the validity of the above-stated prediction.

C H A P T E R I I

THE EXPERIMENT

The purpose of this experiment is to determine the effect on blocking of a change in the site of US application (producing a change in the elicited response) in the transition from Stage I to Stage II of the blocking procedure, using a rabbit NMR preparation. To the extent that a change in the response elicited by the US caused by a shift in the US locus is crucial to conditioning, then to that extent might one expect an attenuation of blocking.

Methods

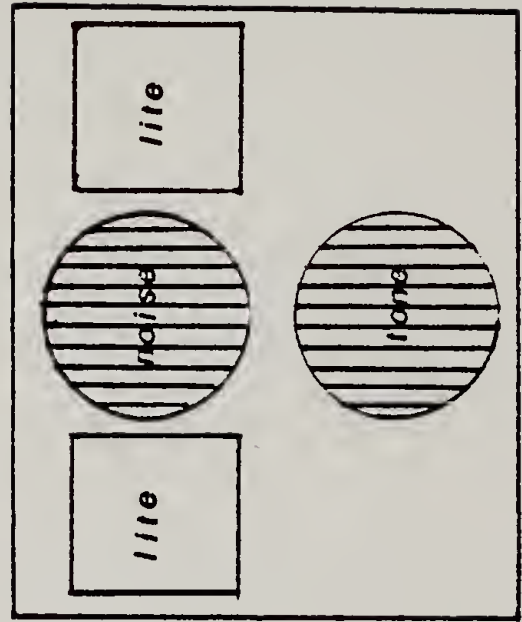
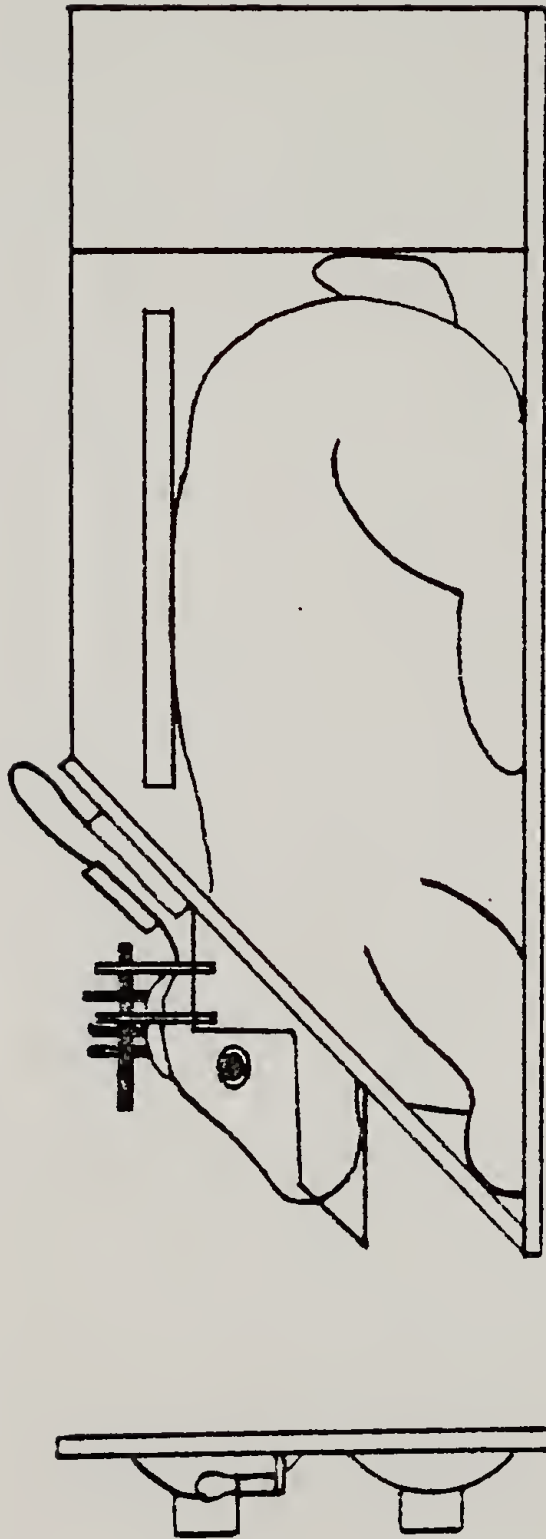
Subjects. Twenty-seven experimentally naive New Zealand rabbits, obtained from a local supplier, served as the subjects. Subjects were assigned to one of three groups.

Apparatus. The apparatus and methods used to condition the rabbit NMR were essentially identical to those described by Gormezano (1966). Two rabbits were run simultaneously in a ventilated, sound-attenuating filing cabinet, one animal to a drawer. The responses of both nictitating membranes of each animal were monitored via mini-torque potentiometers (Conrac, Model 85153) mounted on both sides of the front panel of a Plexiglass restraining box, where each animal was held during conditioning trials. The restraining box was identical to that described by Gormezano (1966): a three-sided rectangular box with a slanted front

cut out so as to accept a sliding yoke, and slotted sides which accepted spring-loaded backplates for adjustable restraint. The box was altered in the following manner. To the front panel of the box was attached a Plexiglass platform with small side panels. Two vertical threaded bolts were tapped into the side walls of the platform. A Plexiglass platform, with a hole in its center and with adjustable sleeves placed over the holes, was attached to four long bolts and could be rigidly connected to the platform on the restraining box. Bolts placed on the rabbit's head could be slipped through the channels in the sleeves and secured to the upper platform. Figure 1 is a sketch of the restraining box used. The modifications ensured that the rabbit's head was immobilized at all times.

The potentiometers were attached to the membrane via nylon loops sutured to the membrane. The loops were connected to the lever arm, and attaching hook of the potentiometer. A nictitating membrane response was defined as a 1 mm upward deflection of a Grass 5D oscillograph pen, which would be generated by a slightly more than .5 mm movement of the membrane. The CS elements consisted of a 76 dB 1200 HZ pure tone, presented via a speaker mounted centrally on a front panel on the file cabinet drawer, and two flashing 6V dc lights (10 HZ) mounted behind translucent white screens. The compound CS consisted of the simultaneous presentation of both stimulus elements. White noise at 65 dB was continuously presented via a speaker mounted directly above tone CS speaker. The time between the CS onset and the US onset was a constant 450 msec. The US was a 1-ma shock of 50 msec duration

Fig. 1. Schematic diagram of the restraining apparatus and its position with respect to the stimulus panel when placed in the conditioning chamber. Also shown is a front view of the stimulus panel as seen by the rabbit.



delivered via two stainless steel wound clips implanted superficially in the skin; one immediately below and the other immediately posterior to the eye.

Surgery. Three 2 1/2 inch long no. 4-40 machine screws were secured to the skull by implanting the bolts head down in an acrylic cap secured by the heads of smaller 4-40 machine screws fastened to the skull. Approximately one hour before surgery, each rabbit was injected with 12 mg/kg body weight of Thorazine (IM) to potentiate the effects of Nembutol anesthetic (IV, 20-25 mg/kg, diluted with physiological saline). Prior to placing the rabbit in a large Kopf (model 1230) stereotaxic frame equipped with a rabbit adapter, the rabbit was injected with Xylocaine near the zygomatic arches and in the scalp.

After placement in the stereotaxic frame a 5-6 cm midline incision was made, extending caudally from between the eyes. The skull was then exposed cleaned and dried. Three 1/4 inch 4-40 machine screws were then inserted in the skull, two caudal to bregma and on either side of the midline, and one rostral to bregma. The large bolts were positioned via an electrode carrier, upside down on the surface of the skull and the bolts and screws were cemented together with the construction of a large acrylic cap. Each rabbit was given a minimum of ten days to recover from surgery prior to being run in the experiment.

Procedure. All animals had suture loops attached to both NMs and were habituated to the restrainer and chamber for two 50 minute periods prior to the first conditioning session. Each conditioning session

consisted of 100 trials at an intertrial interval of 30 seconds. The rabbits were run in four squads of six each, and one squad of three over a period of several months. Within each squad the rabbits were randomly assigned in equal number to three groups.

Rabbits in the Switch group received daily conditioning sessions to the tone CS in Stage I until four days of 90% CRs (on the average) had occurred. Throughout Stage I the shock US was delivered to the left paraorbital region. Each rabbit of the Block group received the same Stage I set of procedures, but received the US in the right paraorbital area. Each rabbit of the control group was yoked to the other groups in terms of equal exposure to the conditioning apparatus. These animals were simply placed in the restrainer and chamber for an equivalent number of days during Stage I, but did not experience any USs until Stage II. All animals experienced the same conditions in Stage II--five daily sessions of 100 trials with the light-tone compound, with the US delivered to the right paraorbital region at the same intensity, duration, and interstimulus interval. After Stage II training all animals were given two successive days of testing which consisted of 50 unreinforced presentations of the tone CS randomly interspersed with 50 unreinforced presentations of the light CS. The experimental design is summarized in Table 1.

EXPERIMENTAL DESIGN

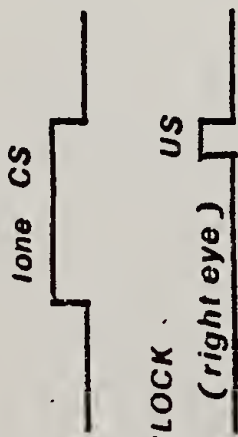
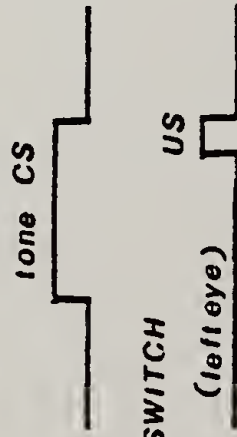
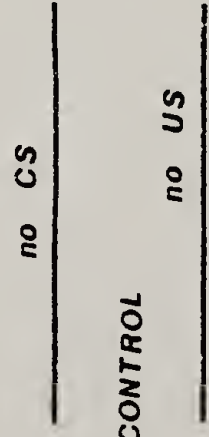
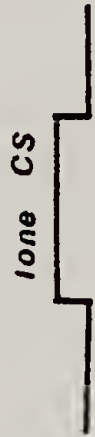


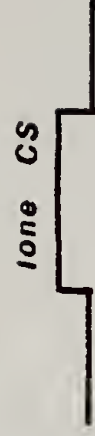


STAGE I	STAGE II	TEST
<p>tone CS</p>  <p>BLOCK (right eye) US</p> <p>tone CS</p>  <p>SWITCH (left eye) US</p> <p>no CS</p>  <p>CONTROL no US</p>	<p>tone CS</p>  <p>tone CS</p> <p>light CS</p>  <p>light CS</p> <p>ALL GROUPS</p> <p>US (right eye)</p>  <p>US</p>	<p>tone CS</p>  <p>OR</p> <p>light CS</p>  <p>light CS</p> <p>ALL GROUPS</p> <p>no US</p>  <p>no US</p>

Table 1. Design of the experiment, with all groups represented

Results

Stage I results. The results of Stage I training are shown in Table 2. Measures of acquisition, and asymptotic performance for the shocked and unshocked eyes of both experimental groups are displayed. Presumably, the acquisition of the NMR during Stage I would be identical for both groups, but different for the shocked and unshocked NMs, irrespective of group membership.

The first column of Table 2 shows that both the Switch and the Block groups reached criterion in eight to nine days on the average. The differences between the two groups on this measure of acquisition was not significant ($t(16) = -0.42, p > .05$). As shown in column 2, the mean percentage CRs by the shocked NMs for the last four days of training was 91.3% for the Block group and 91.7% for the Switch group, and the difference was not significant ($t(16) = 0.17, p > .05$). As shown in column 3, the mean percentage CRs from the unshocked NMs over the last four days was 12.2% for the Block group, and 5.8% for the Switch group. While there were more unshocked NMRs produced by the Block group, the difference does not approach significance ($t(16) = 1.23, p > .05$).

As shown in the fourth column, the CR latencies in the shocked NMs for the Block and the Switch groups were 317 msec. and 320 msec., respectively, during the last session. As shown in the fifth column, the CR latency in the unshocked NM averaged 415 msec. and 404 msec. respectively, for the Block and Switch groups. The difference in CR la-

GROUP	DAYS TO CRITERION	% CRS, last 4 sessions shocked eye	% CRS, last 4 sessions unshocked eye	CR latency of shocked eye: last session (msec)	CR latency of unshocked eye: last session (msec)
CONTROL					
BLOCK	$\bar{X} = 8.2$ S.D. = 4.3	$\bar{X} = 91.3$ S.D. = 3.46	$\bar{X} = 12.2$ S.D. = 10.5	$\bar{X} = 317.0$ (msec) S.D. = 59.1	$\bar{X} = 415.7$ (msec) S.D. = 64.5
SWITCH	$\bar{X} = 9.0$ S.D. = 3.6	$\bar{X} = 91.66$ S.D. = 4.8	$\bar{X} = 5.8$ S.D. = 11.5	$\bar{X} = 320.8$ (msec) S.D. = 58.6	$\bar{X} = 404.3$ (msec) S.D. = 62.0

Table 2. Stage I results; means (\bar{X}) and standard deviations (S.D.).

tency between the shocked and unshocked eyes across groups was highly significant ($F(1, 12) = 120, p < .05$).¹ There was, however, no significant difference in CR latency between groups across response type ($F(1, 12) = .087, p > .05$), and no reliable response type by group interaction ($F(1, 12) = .04, p > .05$) was uncovered.

In summary, the Stage I data indicates that there was no difference between the groups during conditioning of the NM to the tone CS, but that the shocked NM displayed much stronger conditioning than the unshocked NM for members of both groups.

Figure 2 illustrates some representative responses from two Block and two Switch animals during the last day of Stage I. The unshocked NMRs were highly variable, ranging from no response by B-5, to a response by B-6 that is equal in latency and nearly equal in magnitude to the response of the shocked NMR. However, not a single animal displayed a CR frequency or an NMR latency in the unshocked NM that equaled those of the shocked NM. The most typical type of unshocked NM response is reflected by the tracings of the NMRs of the two animals in the Switch group.

Stage II results. In order to evaluate the effects of a change in the elicited response (from the left to the right NM) on CR performance by the Switch group, the course of conditioning of the Switch group during Stage II was compared to that of the Block and Switch groups.

Overall course of training. Figure 3 illustrates the mean percentage of CRs from the shocked NM during Stage II for all three groups.

Fig. 2. Representative responses from two Block (B-5, B-6) and two Switch (S-5, S-6) animals during the last day of Stage I. Tracings for the left (l) and the right (r) NMs are shown for each animal, and the locus of the shock is indicated as well (+). The tracings containing downward square-wave deflections indicate the occurrence of the CS.

STAGE I

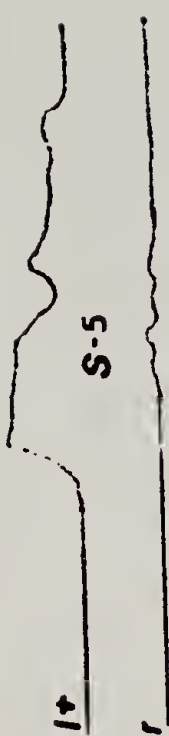
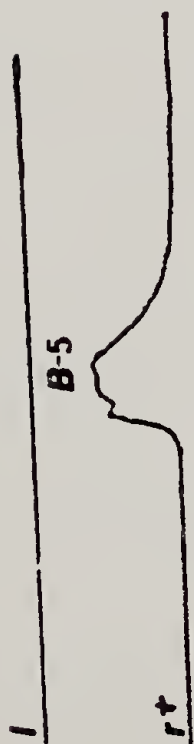
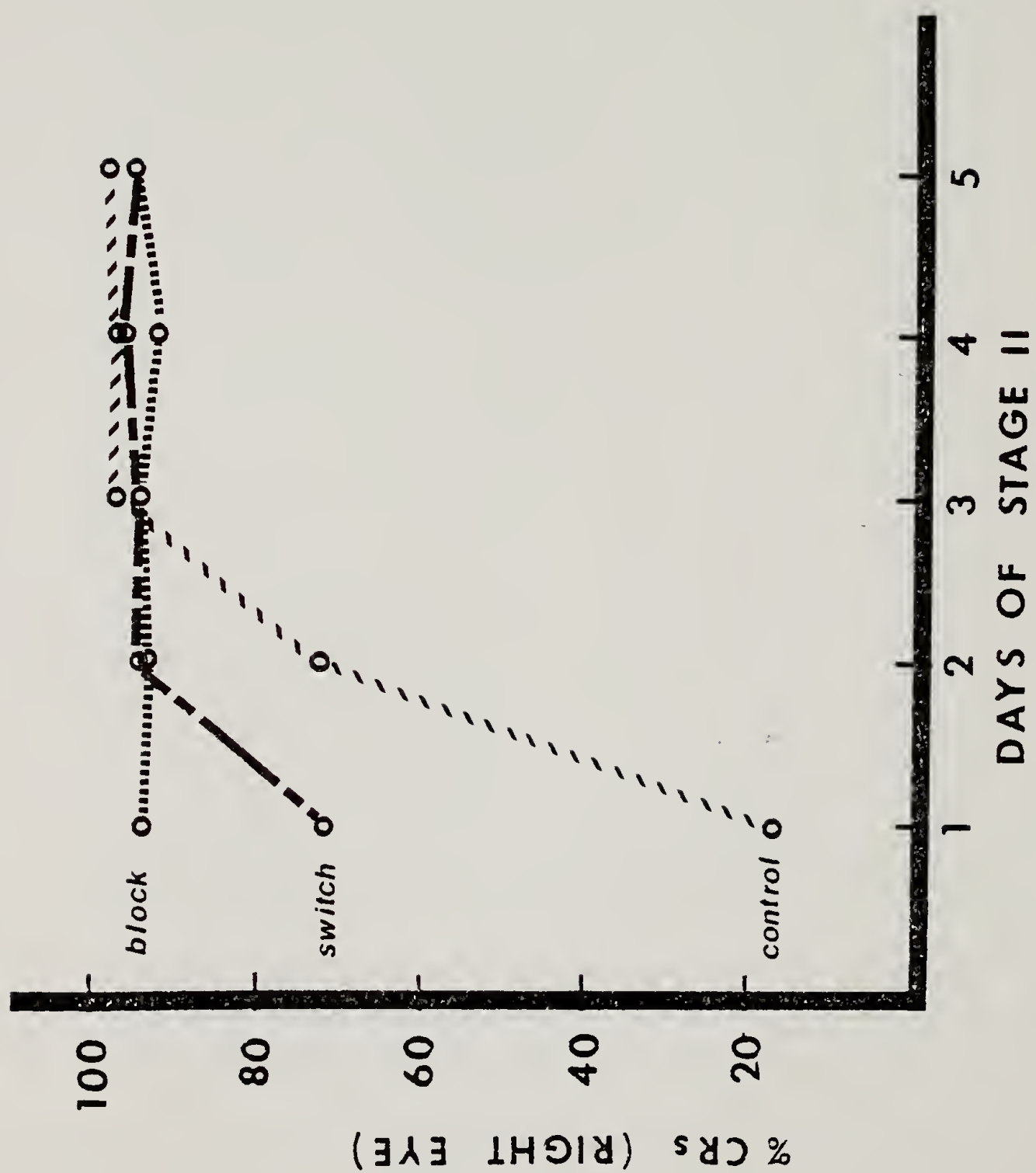


Fig. 5. Mean percentage of CRs from the shocked NM (RIGHT EYE) during Stage II for Switch, Block, and Control groups. The percentage CR values are plotted as a function of the days of Stage II.

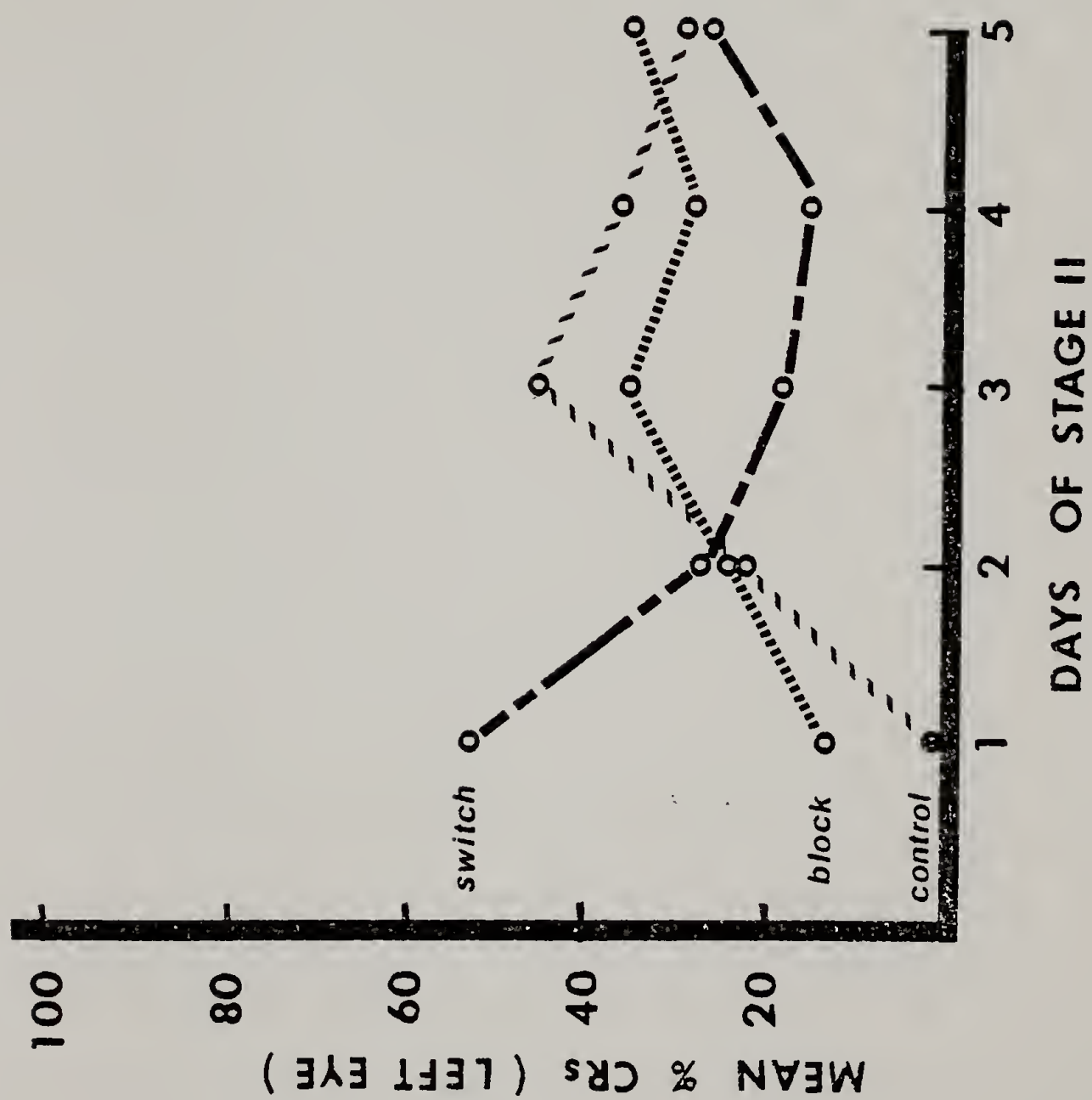


The Block group was unaffected by the transition from Stage I to Stage II and maintained a CR level of more than 90% for the five days of Stage II. The Switch group shows a decreased percentage CR level on the first day of Stage II (i.e., below that obtained on the last day of Stage I) as result of the transition, but recovered to previous levels on Day 2. The animals of the Control group initially displayed the lowest percentage CR performance, and required the most days of training to reach the 90% level.

Figure 4 illustrates the mean percentage of CRs per day for the unshocked NM of each group. Note that the curve for the Switch group shows what appears to be a declining percentage of responding in the previously shocked NM. Note also that the other two groups (Block and Control) display a negatively accelerated increase in percentage CRs in the unshocked NM, and that all three groups moved towards an asymptote of about 30% CRs by the fifth session.

In order to determine if the response trends in the shocked and unshocked NMs across and within groups were significantly different, a mixed-design analysis of variance was performed. Group membership was the between-subjects variable, and days and shock locus were the within subjects variables. The analysis uncovered significant main effects of shock locus ($F(1, 24) = 199, p < .05$) and days ($F(4, 96) = 16.6, p < .05$) on CR frequency. More importantly, there were also significant group by days ($F(8, 96) = 13.3, p < .05$) interactions. These significant interactions indicate that differences in the course of conditioning as a function of training were reliable.

Fig. 4. Mean percentage of CRs from the unshocked NM (LEFT EYE) during Stage II for Switch, Block, and Control groups. The percentage CR values are graphed as a function of the days of Stage II.



Independence of the nictitating membranes. Given the assumption that the NMRs of the rabbit represent the activity of independent systems, it is of interest to determine if the decline in CRs by the unshocked NM (previously shocked in Stage I) and the rapid rise to an asymptote of responding by the shocked eye (unshocked in Stage I), as demonstrated by the Switch group, represent independent processes. A test of independence should indicate whether the activity in the two NMs represents the operation of the separate processes of extinction and acquisition, or an interaction between the two NMs as a result of the change in shock locus. Accordingly, the inverse relationship between the shocked and unshocked NMRs of the Switch group was investigated. Table 3 shows the results of chi-square tests of association done on each Stage II training day, and the results of an overall chi-square for the five days. Each chi-square analysis was based on a two by two contingency table of all combinations of responding and not responding in the shocked and unshocked NMs. The frequencies of the response events in each cell were summed over all Switch animals. The frequencies in the second column of Table 3 represent the cells from each contingency table containing the frequency of trials when a conditioned response occurred in both the shocked and unshocked eye. The frequencies in the third column of Table 3 are estimates of the frequencies in column 2, determined by dividing the product of the two appropriate marginals of the relevant contingency table by the total number of cases in that contingency table.

The tests indicate that the obtained frequency of joint shocked

TABLE 3

Joint Probability of Shocked (sh) and Unshocked (unsh) NM
 Conditioned Responses (CRs), Product of Separate
 Probabilities for CR_{sh} and CR_{unsh} , and Results
 of Chi-Square Tests on Frequencies^a

Days of Stage II	$P(CR_{sh} \times CR_{unsh})$	$P(CR_{sh}) \cdot P(CR_{unsh})$	Yate's Corrected χ^2
1	.382 (344)	.373 (335)	1.369
2	.267 (240)	.252 (227)	14.058*
3	.182 (164)	.173 (156)	6.590*
4	.152 (137)	.146 (132)	5.360*
5	.260 (234)	.246 (222)	16.027*
over all	.248 (1119)	.251 (1130)	1.268

^aFrequencies are given in parentheses in the body of the table.

*
p .05.

and unshocked NMRs was not significantly different from the expected frequency of joint NMR occurrences (see columns 1 and 2 in Table 3) over all five days. The result formally defines the unshocked and shocked NMRs as independent events. The tests of daily observed versus expected frequencies of the joint-response event, however, indicate that the independence of the responses is short lived and occurs most strongly on the first day of Stage II.

CR latencies. In order to make further comparisons in the performance of the three groups in Stage II and to relate Stage I and Stage II performance, CR latencies were obtained and analyzed. Table 4 shows these CR latencies for the shocked and unshocked NMs of all three groups on the last day of Stage II. There was no significant effect of groups across response type ($F(2, 19) = .70, p > .05$)², and no significant response type by group interaction ($F(1, 19) = 30.9, p > .05$). By contrast, the difference between the shocked and unshocked NMs across groups was highly significant ($F(1, 19) = 30.9, p < .05$). A comparison of Table 2 and Table 4 indicates that there was no significant change in CR latency for the shocked and unshocked NMs of the Switch and Block groups from the last day of Stage I to the last day of Stage II. Thus, the asymptotic performance of both groups remained unchanged with the addition of the light CS and the change in the elicited response for the Switch group.

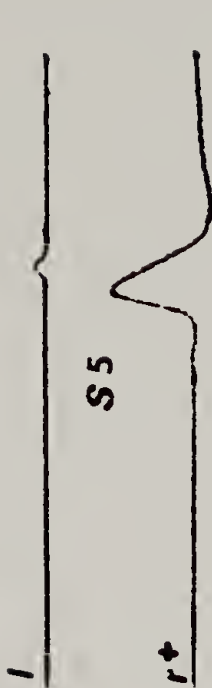
Representative responses during Stage II are shown in Figure 5, for the same animals as in Figure 2. Again, the unshocked CRs are of generally small amplitude and long latency. Note also that the infre-

GROUP	% CRS by shocked eye: session 1	% CRS by unshocked eye: session 1	CR latency of shocked eye: session 5	CR latency of unshocked eye: session 5
CONTROL	$\bar{X} = 18.2$ S.D. = 21.6	$\bar{X} = .11$ S.D. = .33	$\bar{X} = 293.5$ (msec) S.D. = 48.9	$\bar{X} = 382.8$ (msec) S.D. = 79.4
BLOCK	$\bar{X} = 93.4$ S.D. = 6.0	$\bar{X} = 12.6$ S.D. = 23.8	$\bar{X} = 338.5$ (msec) S.D. = 31.7	$\bar{X} = 389.57$ (msec) S.D. = 79.53
SWITCH	$\bar{X} = 71.2$ S.D. = 29.2	$\bar{X} = 53$ S.D. = 21.94	$\bar{X} = 332.8$ (msec) S.D. = 73.4	$\bar{X} = 427.3$ (msec) S.D. = 99.1

Table 4, Stage II results; means (\bar{X}) and standard deviations (S.D.).

Fig. 5. Representative responses from two Block (B-5, B-6) and two Switch (S-5, S-6) animals during the last day of Stage II. Tracings for the left(l) and the right(r) NMs are shown for each animal, and the locus of the shock is indicated as well (+). The tracings containing the occurrence of the CS.

STAGE II



quent large-amplitude response of B-6 have disappeared from Stage II.

Test results. These results are of most interest, for they should indicate whether a change in the elicited response due to the change in US locus (experienced by the Switch group) might produce more control of responding by the light CS in the Switch group relative to the Block group. If blocking is attenuated one should ask whether the attenuation is complete or only partial; comparisons of the Switch group with the Control group based on responding to the light CS will have relevance to this question.

There are two possible metrics for the analysis of control of responding by the light stimulus. The first is the average percentage of CRs by each group to the light CS as it is presented alone in testing. The second measure is the percentage of CRs to the light CS relative to the percentage of CRs to the tone. The latter is the measure of preference for the following reasons: (a) it controls for individual differences in responding and (b) it incorporates a measure of the control by the pretrained CS as well. Nevertheless, the "absolute" measure of percentage CRs will be examined as well for the tone and the light CS. In this case, the difference between responding to tone and responding to light, as a function of group membership, will be of interest.

Relative responding to the light CS. A relative measure of responding to the light CS consistent with the above notions is the following: the percentage of CRs to light divided by the sum of the

percentage of light CRs and the percentage of tone CRs. The larger this ratio, the greater the control by the redundant stimulus. This ratio may range from 0.0 to 1.0; these extreme values (or limits) respectively represent (a) complete blocking and (b) no control by the tone CS. Figure 6 is a plot of each animal's relative responding in the shocked NM to the light CS, for each group. Each circle represents one animal.

An analysis of variance uncovered significant group effects ($F(2, 24) = 11.07, p < .05$). A post-hoc analysis using Tukey's WSD procedure indicated that these effects were manifest in significantly larger mean ratios (.32 and .43) for the Switch and Control groups as compared to the Block group (.07), and that the difference between the Switch and Control groups was not reliable.³ Thus changes in the eye from which the NMR was elicited as a result of the US locus change at the start of Stage II completely attenuated blocking.

The unshocked NM responding during testing was also analyzed using the above-mentioned relative response measure. Figure 7 illustrates the relative responding to the light CS by the unshocked NMs of the animals of all three groups. Each triangle represents one animal. There were no significant group effects on the relative responding to the light by the unshocked NMs of the animals of all three groups. There were no main effects on the relative responding to light ($F(2, 24) = 2.25, p > .05$), and no significant differences were uncovered via the Tukey procedure.⁴ The data from only 16 subjects were available for this analysis since 11 subjects failed to respond to either the tone or the

Fig. 6. Scatter plot of individual relative responding to the light (LIGHT CRs/LIGHT CRs & TONE CRs) as a function of group membership (CONTROL, BLOCK, or SWITCH) during testing. Each circle represents the behavior of the shocked NM of one animal.

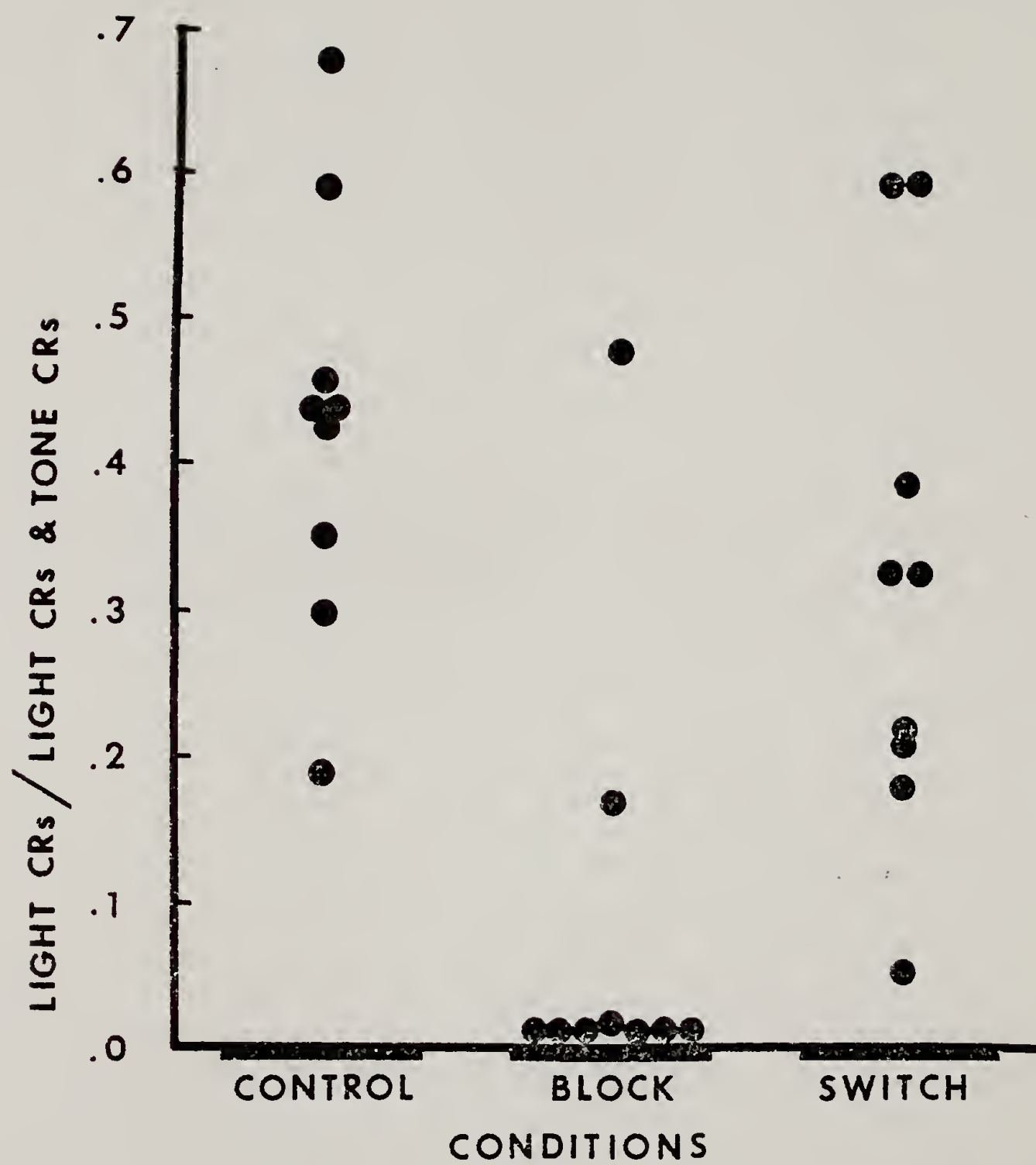
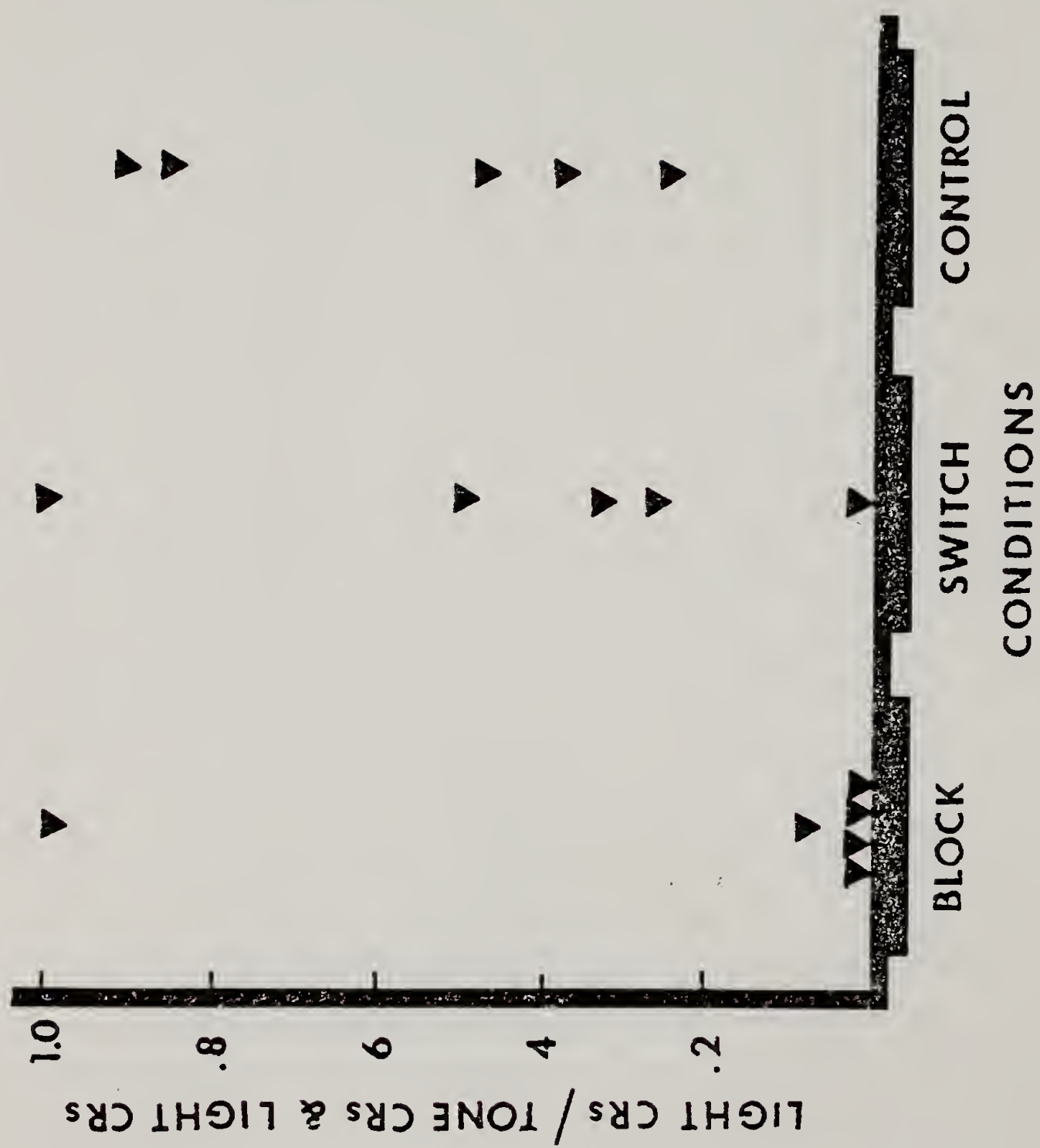


Fig. 7. A scatter plot of individual responding to the light (LIGHT CRs/LIGHT CRs & TONE CRs) as a function of group membership (BLOCK, SWITCH, or CONTROL) during testing. Each circle denotes the behavior of the unshocked eye of one animal.



light, making calculation of a relative response ratio to light impossible.⁴

Absolute responding to the light and tone. The percentage of CRs to the tone and the light CSs by the shocked NM (Stage II) is shown in Figure 8. The light CS was responded to most by the Control group (a mean of 31.3% CRs) and least by the Block group (a mean of 5.4%). The tone CS was responded to most by the Block group (a mean of 43.8% CRs) and least by the Switch group (a mean of 29.7% CRs).

A two-way analysis of variance, with groups as the between subjects variable and type of CS presented as the within subjects variable, was performed. The analysis failed to uncover significant effects of group ($F(2, 24) = 1.18, p > .05$), but did find a reliable main effect of CS type ($F(1, 24) = 19.55, p < .05$). Most importantly, the analysis uncovered a significant group by CS interaction ($F(2, 24) = 4.41, p < .05$). This interaction effect is of most interest in trying to determine whether blocking is attenuated in the various groups.

The interaction effect was further analyzed via post hoc orthogonal contrasts, which indicated that the Block group's differential responding to the light and tone was reliably different from that of the Control and Switch groups, while the Switch and Control groups did not differ reliably from each other in their responding to the CSs. The results of this analysis are consistent with the notion that changes in the eye from which the NMR was elicited as a result of US locus change is accompanied by an attenuation of blocking.

Figure 9 presents the percentage of CRs by the unshocked NM to

Fig. 8. The mean percentage of CRs by the shocked NM to the tone(T) and the light(L) CSs as a function of group (CONTROL, BLOCK, or SWITCH) during testing.

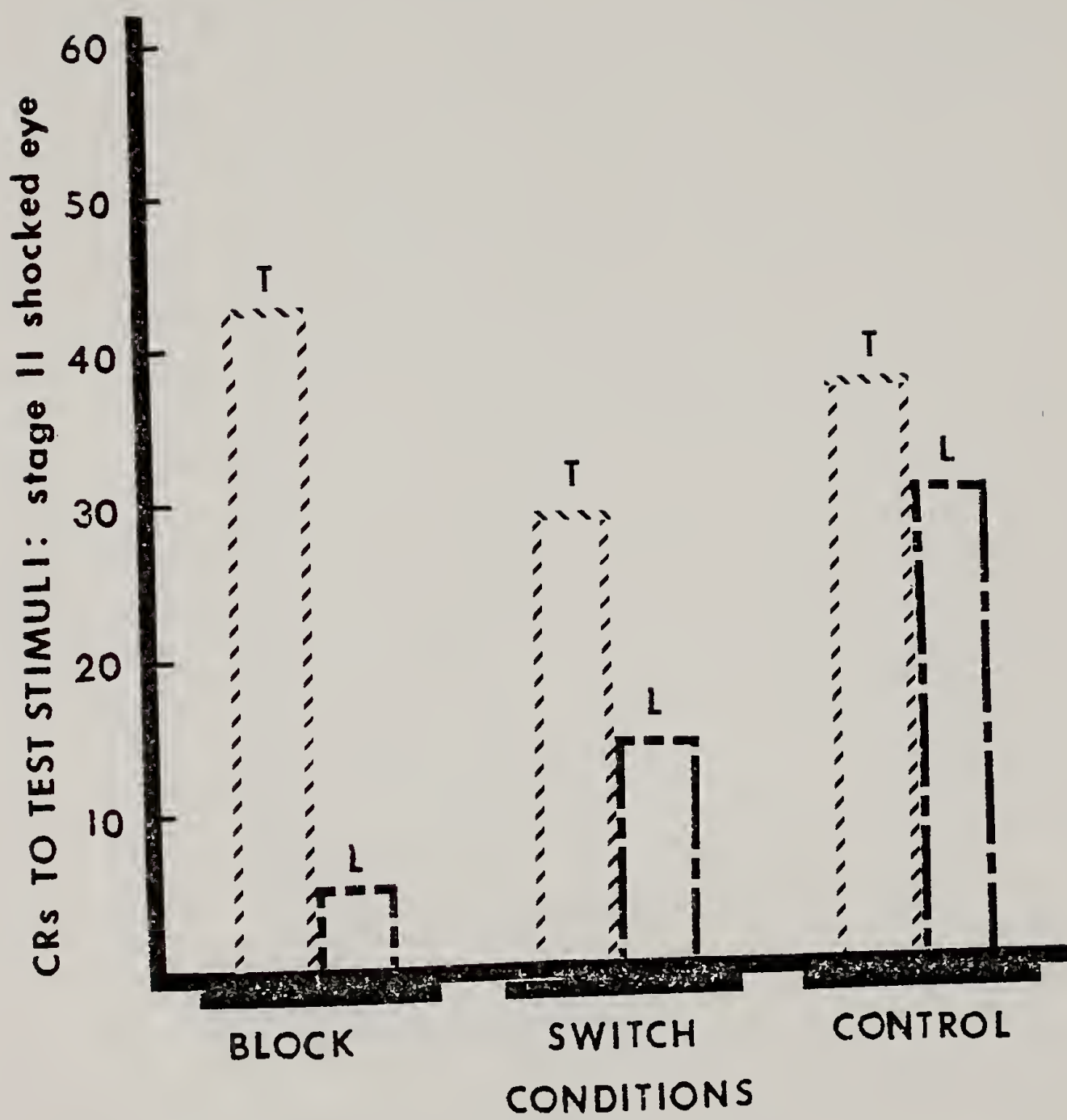
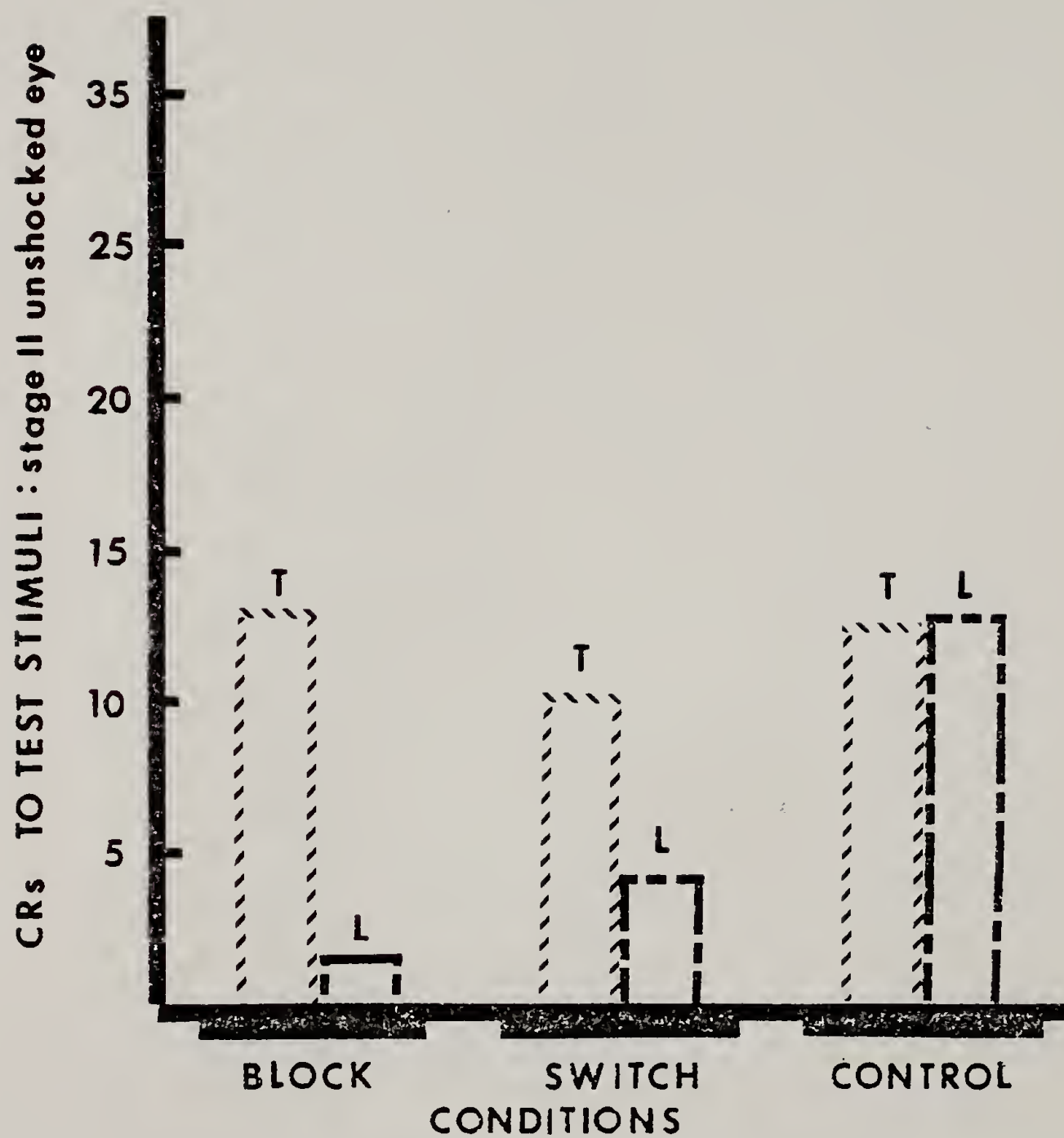


Fig. 9. The mean percentage of CRs by the unshocked NM to the tone(T) and the light(L) CSs as a function of group (BLOCK, SWITCH, or CONTROL) during testing.



the tone and the light. Note that the absolute levels of responding are lower for the unshocked NMs of all three groups, as compared to the shocked NMR percentages shown in Figure 8. However, the relationships of percentage CRs to tone and light, between groups and within groups, are quite similar to those seen with the shocked NMR. An analysis of variance identical to that performed on the shock NM CRs failed to uncover main effects of either group ($F(2, 24) = .25, p > .05$) or CS type ($F(1, 24) = 1.82, p > .05$). There was also no significant interaction of group and CS ($F(2, 24) = .77, p > .05$). These data indicate that the unshocked NMs did not condition strongly to either CS, thus showing no effects of training, which is consistent with the fact that CS presentations were not paired with shock to that NM during Stage II.

Relation between individual performance and degree of responding to the novel CS. The results of testing indicate that the Switch and Control groups did not differ in their relative response to the redundant light CS, and that both groups responded more to the light than the Block group. Nevertheless, the Switch group as a whole responded somewhat less and somewhat more variably to the light than the Control group (see Figure 6). Slightly less control by the light CS over the responding of Switch animal may reflect slightly more control by the tone CS over the newly shocked NM as a result of Stage I training. The difference could be due to the following: (a) "central transfer" of the CS/US relationships established in Stage I to the newly shocked NM in Stage II (see Kettlewell, et al., 1974), (b) some conditioning of the unshocked NM during Stage I, or (c) some combination of both. Avail-

able measures that may reflect these factors are (a) the percentage of CRs in the shocked NM on the first day of Stage II, (b) the latency of the unshocked NM during the last day of Stage I, and (c) the percentage of CRs in the unshocked NM on the last four days of Stage I.

If control by the tone CS and the amount of relative responding to tone are related then there ought to be a correlation between the above mentioned measures and the relative amount of responding to the light for members of the Switch group. One might expect that those Switch animals responding at a low frequency in the newly shocked NM on the first day of Stage II should show the greatest unblocking, as represented by the relative ratio of responding to the light. Similarly, Switch animals who showed higher percentages of responding or shorter latency responding in the unshocked NM during Stage I should show less relative responding to the light in testing.

Table 5 is a matrix of correlations of the measures of "central transfer", and Stage I conditioning of the unshocked NM with the relative response ratio to light. As can be seen, none of the correlations of interest (i.e., those in column 4) was high. Not surprisingly, the correlations of the measures of central transfer and Stage I conditioning with each other were rather high. The CR latency in the unshocked NM during the last day of Stage I was correlated -0.58 with percentage CRs in the same NM (now shocked) on Day 1 of Stage II, and was correlated -0.66 with percentage CRs on the unshocked NM during the last four days of Stage I. Similarly, the percentage CRs in the shocked NM during the first day of Stage II correlated 0.94 with the percentage

TABLE 5

Correlations between "Unblocking" and the Behavior
of the Nictitating Membrane (NM) shocked in
Stage II, for members of the Switch Group

	% CRs ^a Stage I Unshocked NMR	Stage I ^b Unshocked NMR Latency	% CRs ^c Stage II Shocked NMR	Relative Response to Light
% CRs Stage I Unshocked NMR	—	-0.66	0.94	-0.06
Stage I Unshocked NMR Latency	—	—	-0.58	-0.13
% CRs Stage II Shocked NMR	—	—	—	-0.05
Relative Response to Light	—	—	—	—

^a Only the last four days of Stage I.

^b Only the last day of Stage I.

^c Only the first day of Stage II.

CRs of the same NM when unshocked in Stage I. In other words, those Switch animals who showed the greatest responding in the unshocked NM during Stage I most rapidly acquired the CR in the newly shocked NM during Stage II.

These correlations suggest that there is a high degree of consistency among measures of Stage I and Stage II performance in the Stage I unshocked NM, but these measures have little relevance to the relative responding to light in testing. These results should only be tentatively accepted, however, since the size of the Switch group ($n = 9$) does not bestow much power on the analysis.

Discussion

The major findings of this experiment are (a) that a change in the response elicited by the reinforcer as a result of a change in locus of application for that reinforcer attenuates the blocking of a light by a tone and (b) that the attenuation appears to be complete.

The role of the response and the reinforcer. The finding that a change in the elicited response as a result of a change in US locus will attenuate blocking is an important datum, which theories of blocking must account for. Such explanations of this result would, however, require some specification of the relative contributions of the response change and US locus change to the unblocking result. Is either factor solely responsible for unblocking or are both necessary? If the NMRs of the rabbit were independent responses, then one could not assert that a

change in response was a contributing factor. Similarly, if it can be argued that a change in US locus is a qualitative one, and that such changes are not sufficient to attenuate blocking, then the importance of the change in shock locus is diminished.

The response. In point of fact, the change in the elicited response cannot be dismissed as a factor in this study, since the present results indicate that the NMs of the rabbit do function independently. There was a significant difference between the unshocked and the shocked NM in both the frequency and the latency of the CRs: the unshocked NMR was minimal and infrequent. Also, very different processes seemed to be reflected in the behavior of the shocked and unshocked NMs of the Switch animals during the initial sessions of Stage II. The previously shocked NM appeared to be undergoing extinction and the newly shocked NM appeared to be undergoing acquisition. This trend was particularly strong on the first two days of Stage II. This is contrary to the behavior of the NMs of the Block and Control animals, where similar processes seemed to be going on in both eyes--rapid, increasing, large changes in CR frequency by the shocked NM and small, slow increases in responding in the unshocked NM. Finally, the NMs displayed statistical independence.

It is true that on closer inspection the independence of the two response systems on the Switch animal is restricted to Day 1 of Stage II (see Table 3). This short-lived independence may be considered sufficient, since it indicates that the NMRs are not necessarily linked. Even if this were argued not to be sufficient, it still may be countered

that a change in the processes affecting the previously shocked NM of the Switch animals during Stage II obscures the real independence of the two eyes. The unshocked NMs of the Switch animals initially exhibit a rapid decrease in response frequency followed by a slow increase up to the levels shown by the Block and the Control groups (see Figure 4). Such a performance suggests that extinction-related processes (reflected by the decrease in CRs in the unshocked eye) operating in the unshocked NM are replaced by acquisition-related processes (reflected by the slow increase in responding) as Stage II continued.

Those acquisition-related processes operating in the unshocked NM would not be expected to differ from those operating on the shocked NM. A single process acting on both NMR would not necessarily allow independent performance in two response systems that may still be separately activated. This would explain the short-lived statistical independence by the NMs of the Switch animals, and the complete lack of independence exhibited by the Block and Control animals. In any case, the results of this experiment do provide strong evidence for the independence of the NMs of the rabbit.

The reinforcer. As for the role of changes in shock locus in the attenuation of blocking, it seems reasonable to assume that such a change in the present study was indeed qualitative, for the following reasons. First, there was no change in other US parameters in the transition from Stage I to Stage II, such as intensity, duration, and temporal contiguity. Secondly, the change in US locus did disrupt CR percentages at the start of Stage II, but did not result in any difference in

the asymptotic performance level between Stage I and Stage II in the NM that was being shocked.

Given that the change in shock locus represents a qualitative change, it is instructive to look in more detail at the Bakel, Johnson, and Rescorla (1974) study of a change in US quality without a change in the response and its effect on the blocking result in a CER design. They investigated the effect of changes from a klaxon to a shock US and vice versa (from shock to klaxon) in the transition from Stage I to Stage II, as compared to blocking procedures run with no change in the US (klaxon to klaxon, and shock to shock). The appropriate control groups were run as well, with one or the other US. The changes from klaxon to shock and vice versa represent not only changes in the nature of the US, but changes in the locus of application as well. Clearly, the shock US had its effect on the cutaneous sensory system, and the klaxon US would have its effect on the auditory sensory system.

The results of their study were as follows. The klaxon-klaxon and shock-shock blocking groups showed comparable blocking of the redundant CS. However, shifting the US disrupted blocking only in the klaxon-shock transition, not in the shock-klaxon transition. The klaxon-shock transition resulted in less blocking than either the klaxon-klaxon or shock-shock conditions, whereas the shock-klaxon transition resulted in greater blocking than the klaxon-klaxon and shock-shock conditions. Given that comparisons of the control groups indicated greater US potency for the shock, then these results are best interpreted in terms of US potency. The klaxon-shock transition, represent-

ing an increase in US potency, attenuated blocking, and the shock-klaxon transition, representing a decrease in US potency, was found to enhance blocking.

Given these results, one might predict that a qualitative change such as occurred in the Bakel, et al. study, but which left US potency unchanged would leave blocking unaffected. Such a situation is similar to the change in US locus that occurred in this experiment. Thus the results of the Bakel, et al. study argue against the importance of changes in shock locus for the blocking phenomenon.

On the other hand, other studies have argued that qualitative changes in the reinforcer do have an effect on learning. For example, Rescorla (1979) has used a second-order conditioning paradigm with auto-shaped key-pecking in pigeons, in order to study manipulations of the stimulus properties of reinforcers, independent of manipulations of the response properties. This paradigm assumes that (a) aspects of the reinforcer can be separately manipulated (e.g., its response eliciting and its signalling properties), and (b) a first-order CS elicits a US-related response but maintains its own sensory properties (i.e., US-related responses do not interact with CS-related responses that may be affected by manipulations of the CS).

In a rather complicated design, Rescorla purports to show that manipulations of only the stimulus properties of the first-order reinforcing CSs affect the course of conditioning, thus demonstrating the importance of the stimulus features of the reinforcer. Given the particulars of the design, the crucial assumption that the responses to

the different first-order CSs are the same may be unwarranted. First, the first-order CSs were chromatic stimuli presented on different halves of the response key, and were separated by a vertical black line. In the second stage of training the differential conditioning was such that presentation of a vertical black line on the key was not paired with food while the hue stimuli (composed of a hue and the vertical black line) were reinforced. Thus the presence of one stimulus element (i.e., either hue stimulus) from a compound stimulus of several elements (i.e., the key, the black line, the two halves of the key) serves to signal reinforcement. Conversely, the other elements serve to signal non-reinforcement in the absence of the positive elements.

This sort of "feature positive" arrangement can lead to key pecks directed to different parts of the key (e.g., Jenkins and Sainsbury, 1970). Since the two first-order stimuli appeared on different parts of the key, topographically different responses could have been controlled by them. Later manipulations of these reinforcing stimuli in a second-order procedure would be likely to affect any directed responding controlled by these stimuli. Therefore, any effects of manipulating the first-order CSs on the conditioning of the second-order CSs may not be attributable solely to the stimulus features of these stimuli.

Conclusions. To summarize the preceding sections, it appears that the evidence for the importance of qualitative changes in the reinforcer in the attenuation of blocking is unclear, and evidence against it is strong only to the extent that one can justify viewing all changes in reinforcer locus as identical. This latter view may not

be justifiable, since one could argue that the question of whether the US locus change in a CER procedure as used by Bakel, et al. is identical to the US locus change in the present experiment is an empirical one, which the present results do not answer, since unblocking did occur in the presence of a change in shock locus. Similarly, since the independence of the NMRs of the rabbit has been demonstrated it is not possible to rule out a change in the elicited response as a factor contributing to the attenuation of blocking. In short, the contribution of either factor, response change or shock locus change, to the unblocking result cannot be ruled out, until procedures are devised to isolate one manipulation from the other in the rabbit NMR preparation.

Implications for models of conditioning. Other aspects of this study deserve some discussion as well, namely:

(a) The similarity of percent CRs to the tone for the Block and Switch groups during testing.

(b) The absence of significant correlations between measures of "central transfer" and Stage I unshocked NMR conditioning with the relative response to light.

Both of these results may be relevant to models of conditioning that seek to explain the blocking effect.

Similarity of percent CR measures. Of theoretical interest is the lack of difference between the Block and Control groups in the percentage of CRs by the shocked NM to the tone during testing (see Figure 8). The Rescorla-Wagner model (Rescorla and Wagner, 1972), with its

assumption that stimuli compete for associative strength, would predict that the Control group's greater percentage responding to light in testing would be at the expense of responding to tone in testing. Therefore, the Control group should show greater control by light but less control by tone as compared to the Block group. Instead, the Control and Block group displayed equal responding to tone. The Mackintosh (1975) formulation, an attentional analysis of blocking, does not require the same sort of result since in that model the stimuli do not compete for associative strength. There are, however, explanations of this result that appeal solely to non-associative factors; thus the theoretical implications of this result are not so compelling.

The shorter CR latencies of the Control group in Stage II, as compared to those of the Block group (see Table 2), suggest that the CS/US pairings generated a higher level of performance in a group that had received less overall training than the Block group. Moreover, comparisons of the CR latencies of the Block group from the last day of Stage I to the last day of Stage II show that while the unshocked NM latencies decreased, the shocked NM latencies increased. The latency increase in the shocked NM only approached significance, but the trend is there, as it is for the Switch group as well.

These increases suggest that the mild US used in this study may lose some of its effectiveness in supporting the conditioned response. This suggestion is supported by some evidence that CR latency is a decreasing function of US intensity, and that CR latency might be con-

sidered a measure of changes in the strength of conditioning (e.g., Smith, 1966). In the terms of the Rescorla-Wagner model, the level of conditioning supportable by the US may decrease with extended training. Specifically, habituation to the mild CS may be taking place; habituation to repeated presentations of a moderately strong stimulus is a well-known and nearly universal phenomenon (e.g., Bindra, 1959; Harris, 1943; Humphrey, 1933; Ratner, 1970). Therefore, the generally higher than expected level of responding to the tone by the Control group during testing may be simply a function of the Block group's greater exposure to processes that reduce the effectiveness of the US.

Alternatively, the higher than expected responding to the tone by the Control group might reflect differences in reflex excitability to the tone, resulting from differences between the Block and Control groups in the extent of training. Young, Cegavske, and Thompson (1976) demonstrated that during the acquisition of CRs to a tone CS, the reflex excitability of the abducens motoneurons to tonal stimulation appeared to decrease over trials, in spite of the steady increases in conditioned responding. Assuming that such decreases in reflex excitability might have significant effects on responding to the unreinforced tone during testing the Block group's more extended exposure to the tone CS may have reduced the number of CRs to the tone in testing, so that the Control and Block groups exhibited equivalent tone responding. In any case, the availability of non-associative explanations robs this result of much of its theoretical impact.

The absence of significant correlations. This circumstance (see Table 5) presents problems for quantitative implications of the Rescorla-Wagner model (cf. Prokasy and Gormezano, 1979). The quantitative aspects of the model would make particular predictions concerning the relationship between Stage I/II performance and test results, depending upon the assumptions that are made about the relationship between associative strength and responses. If associative strength is response-specific, then Switch animals with higher levels of unshocked NMRs during Stage I should have acquired significant associative strength between tone and shock in the response system of the unshocked eye. If the associations are not response-specific, then Switch animals exhibiting more rapid acquisition of CRs during Stage II in the previously unshocked NM may have experienced less disruption of the associations between shock and tone as a result of the change in the response elicited.

In either case, any associative strength available at the start of Stage II should result in a smaller discrepancy between the current level of associative strength and the maximum amount supportable by the US in that same response system once the shock is transferred there at the start of Stage II. This circumstance would allow less associative strength to accrue to the light CS during Stage II. Therefore, the Rescorla-Wagner model would predict that higher CR levels on Day 1 of Stage II and/or higher levels of responding in the unshocked NM during Stage I should be associated with lower levels of responding to light in testing.

Mackintosh's (1975) formulation would make predictions similar to those of the Rescorla-Wagner model. According to Mackintosh's model, the salience of a stimulus A changes as a result of the relative predictive power of that stimulus, where the predictive power is described as $|\lambda - V_A|$. The smaller the difference between the associative asymptote (λ) and the associative strength (V_A), the greater the predictive power of stimulus A.

If it is assumed that predictive power is not response specific, then the course of conditioning during Stage II for the Switch animals should reflect how much the predictive relationship between the tone and the US is maintained in the transition from Stage I to Stage II. More specifically, more rapid acquisition of the CR in the Stage I unshocked NM by a Switch animal during Stage II could be the result of lower values of $|\lambda - V_{\text{tone}}|$ and therefore greater predictive power by the tone for that animal. If the predictive relationship between tone and shock is strong at the start of Stage II, then the light CS loses salience in Stage II. A loss of salience by the light CS will limit its control over the response. In other words, high levels of CR production on Day 1 of Stage II should be associated with less relative responding to light, and vice versa.

If it is assumed that predictive power is response specific, then the amount of unshocked NM responding during Stage I should indicate the extent to which the predictive relationship have been developing in the unshocked NM. The greater this relationship at the time of response transfer, the greater the loss in salience by the newly introduced

light CS, since it has no predictive relationship with the shock at the start of Stage II. Greater Stage I unshocked NM responding should therefore correlate with less control of the response by the light.

As Table 5 has shown, the actual correlations between the measures of interest do not bear out the expectations of the Mackintosh and Rescorla-Wagner models. In any case, expectations of particular correlations do not represent strong tests of any model, for several reasons. First, the variables involved in such correlations were not explicitly manipulated by the experimenter, so that causal relations are only assumed. Secondly, the size of the Switch group ($n = 9$) puts constraints on the power of the correlational analysis. Finally, the variability of the measures in question may be due to factors that are non-associative in nature, in which case correlations of these measures are unrelated to tests of these models.

Synopsis. The results of this study suggest that changes in aspects of the reinforcer (shock locus, elicited response, or both) disrupt associations based on these aspects, so that characteristics of redundant conditioned stimuli can be associated with aspects of the reinforcer in procedures that normally prevent such associations. Clearly, the results do not discriminate the relative contribution of the eliciting and signalling properties of reinforcers and other stimuli. The effect of changes in shock locus on the blocking phenomenon, independent of changes in the elicited response, is accessible to investigation, and is the first order of business for further studies in blocking.

FOOTNOTES

¹The four animals (two from each group) that did not respond in the unshocked eye on the last day of Stage I were not included in the analysis since it was not possible to determine an unshocked NMR latency for these animals.

²Five animals (one Control, two Switch, and two Block animals) did not respond in the unshocked eye on the last day of Stage II and thus were not included in the analysis.

³Given the importance of these comparisons, non-parametric tests (Mann-Whitney U) were also performed, which confirmed the nature of the group differences uncovered by Tukey's procedure.

⁴Unequal Ns were corrected for by computing an harmonic mean for the contrasts.

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