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THE EFFECTS OF CUTANEOUS AFFERENT ACTIVITY
ON LATENT LEARNING IN THE BILATERAL
CONDITIONING PARADIGM

by

Michael Francis O'Connell

B. S., University of Michigan, 1970

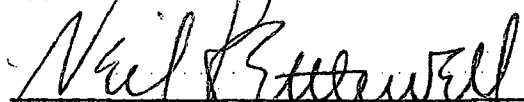
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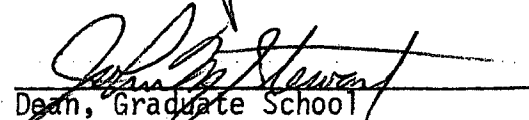
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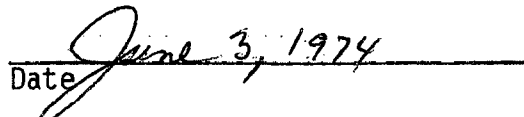
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TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	ii
LIST OF TABLES AND FIGURES	iv
Chapter	
1. INTRODUCTION	1
2. GENERAL METHOD	12
Subjects	12
Techniques	12
Apparatus	13
Design	14
Procedure	15
Results	16
3. EXPERIMENT 1	18
4. EXPERIMENT 2	22
5. EXPERIMENT 3	25
6. DISCUSSION	28
7. SUMMARY	30
REFERENCES	31
APPENDIX	37

LIST OF TABLES AND FIGURES

Table	Page
1. Analysis of variance across groups 1-6	17

Figure	Page
1. Performance curves for Initial and Crossover periods for Groups 1, 2 and 3	21
2. Performance curves for Initial and Crossover periods for Groups 4 and 5	24
3. Performance curves for Initial and Crossover periods for Groups 1 and 6	27

CHAPTER I

INTRODUCTION

The development of the literature surrounding classical (Pavlovian) conditioning has proceeded hand-in-glove with the development of psychological learning theory in general. Since Pavlov's initial demonstration of "psychic" secretions (Pavlov, 1902), the phenomenon of classical conditioning has been one of the basic considerations in the construction of the major influential learning theories that have been developed since the turn of the century. Watson (1916), writing in favor of the behaviorist approach to psychology, suggested the use of classical conditioning as a replacement for the techniques of introspection. In his later writing (1925), Watson used the conditioned reflex as the basis of learned behavior.

Guthrie (1930, 1935) took the position that the conditioned reflex (or conditioned response as it had come to be called) was ideally suited as the basic element in his contiguity theory of learning. Much of the theory developed by Hull (1943) has as its base research and hypotheses about the mechanisms of classical conditioning (Hull, 1929, 1937). In recent years, Spence (1956), Razran (1957), and Mowrer (1960) have produced much of the contemporary classical conditioning research and theoretical formulations.

According to Gormezano (1969), the essential element of classical conditioning is a particular set of experimental operations. These include an unconditioned stimulus (UCS) which reliably elicits an unconditioned response (UCR) whose occurrence can be measured and a conditioned stimulus (CS) that has been shown by test not to produce the UCR. The CS and UCS are repeatedly presented to the organism in a predetermined temporal relationship and after several presentations of the CS-UCS combination, a response similar to the UCR develops to the CS which is called the conditioned response (CR). Needless to say, a large number of different temporal arrangements of CS and UCS are possible and these arrangements provide considerable control over the rate of acquisition of the conditioned response. The aspect of the classical conditioning paradigm which distinguishes it from other learning paradigms is the fact that the behavior of the organism in no way affects the presence or absence of the UCS. In the operant or instrumental learning situation, the behavior of the organism may elicit changes in the environment which may be of considerable ecological importance.

In a typical classical conditioning paradigm, therefore, there is a CS, a UCS, a CR, a UCR, and some temporal relationship between the two stimuli. A wide variety of stimulus events have served as conditioned stimuli. Pavlov (1927) used such things as bells, rotating discs, and metronomes, although technically, any environmental change which the organism can detect can be used as a CS (Gormezano, 1969). The experimenter does not have quite as much latitude in

choosing an unconditioned stimulus. Any stimulus event which reliably elicits a measurable response from the organism should be acceptable as a UCS. For example, food placed in the mouth will elicit salivation and a puff of air in the eye will elicit lid closure. Electric shock is employed in many classical conditioning situations because of the large variety of responses which can be elicited with it and because organisms generally adapt to it rather slowly.

Once the duration of the CS and UCS are determined, two other parameters of the classical conditioning situation, inter-trial interval (ITI) and inter-stimulus interval (ISI), are needed to completely define the temporal relationships of the situation. The ITI is defined as the average interval between CS-UCS presentations. The CS-UCS presentation is usually designated a trial. The ISI is defined as the time interval from CS onset to UCS onset. Thus, if the UCS is presented 100 msec after the start of the CS, the ISI is 100 msec. In general, ITIs are measured in seconds or, rarely, in minutes, and ISIs are measured in milliseconds. In the typical classical conditioning situation, where a skeletal muscle response of some type is being conditioned to a tone or light or a bell, good conditioning will be obtained with ISIs approximating 500 msec and ITIs in the range of 30-120 sec.

As mentioned before, classical conditioning has played an important part in the development of psychological learning theories and there are both methodological and theoretical reasons why this is the case. In the first place, in contrast to a number of other learning

paradigms, classical conditioning requires no elaborate pretraining (Gormezano, 1969). It can also be said that classical conditioning is perhaps the most basic form of learning based on the fact that it has reportedly been demonstrated in organisms as diverse as planaria and humans (Jacobson, 1963). Such a widespread phenomenon must certainly be taken into account in any overall theory about the learning of organisms. As an additional advantage, the classical conditioning paradigm allows the experimenter a large degree of control over the parameters of the situation. CS, UCS, ITI and ISI are all explicitly designated by the experimenter.

In general, the learning theories which have been developed have been of two types: stimulus-response (S-R) theories and stimulus-stimulus (S-S) theories. The S-R position maintains that learning consists of the development of associations between stimuli and responses. This approach has been presented at various times by Guthrie (1935), Hull (1943), and Skinner (1938). The S-S position on the other hand, presumes that learning involves the development of associations between stimuli. These types of theories, sometimes called cognitive theories, have had proponents such as Tolman (1937, 1945, 1959), Maier and Schneirla (1942), and Woodworth (1948, 1949). Classical conditioning experiments have played a significant role in the controversy between these two positions. The demonstration of such classical conditioning phenomena as sensory preconditioning (Brogden, 1939), conditioning without peripheral mechanisms (Black, 1965; Black, Carlson and Solomon, 1962), and the presence of preparatory set factors (Razran,

1939, 1949, 1955; Grings, 1960) has had considerable influence on the development and modification of both S-R and S-S theories.

There are a number of reasons why in some situations, infrahuman organisms are chosen as experimental subjects instead of human beings. The primary advantage of animal research lies in the greater degree of control which the experimenter can assert over the experimental situation and the greater number of experimental manipulations which are ethically permissible. It is also the case that animals may be employed in the type of long term experiments in which human subjects could hardly be expected to engage.

In classical conditioning, it is typically necessary to attach some type of monitoring device to the organisms in order to insure the measurement of the CR and UCR. If an experimenter has chosen to use animals in his research, the efficient use of a monitoring device requires the physical restraint of the animal. Unlike the cat and the rat, for example, the rabbit adapts very well to restraint which greatly facilitates the monitoring of the response which the experimenter has chosen. The early rabbit classical conditioning studies used eyelid closure (Schneiderman, Deaux and Gormezano, 1962), movement of the nictitating membrane across the cornea (Gormezano, Schneiderman, Deaux and Fuentes, 1962) and retraction of the eyeball (Deaux and Gormezano, 1963) as the responses to study. Several studies (Bruner, 1963; Papsdorf, Gormezano and Prokasy, 1964; Schneiderman and Gormezano, 1964) have indicated that the albino rabbit is particularly well suited to the restraint required in these classical

conditioning situations. All three of the responses mentioned above have extremely low spontaneous rates of response (about one to three responses per hour) (Gormezano, 1965).

The nictitating membrane is made up of a fold of conjunctiva supported by a triangular sheet of cartilage which moves from the medial canthus of the eye laterally across the surface of the cornea. Extension of the nictitating membrane can be reliably elicited by a puff of air to the cornea or by an electric shock applied to any one of several positions on the head of the animal. The latency of the response is on the order of 25-50 msec and the activated membrane rarely extends past the midline of the pupil (Gormezano, 1965). Although the precise musculature involved in the movement of the nictitating membrane is not completely known, Prince (1964) has stated that movement of the membrane accompanies retraction of the eyeball into the orbit. The return to its resting position is accomplished by the levator palpebrae superioris.

A number of recent experiments have indicated that cutaneous afferent activity (CAA) may play an important role in the classical conditioning of the rabbit's nictitating membrane response. Learning (Kettlewell and Papsdorf, 1971), performance (Kettlewell, Berger and Pezzino, 1973) of the nictitating membrane response have been shown to be profoundly affected by manipulation of the levels of CAA in the orbital region of the eye. Conventional learning theory would appear to have no adequate way of dealing with these findings. The great bulk of the classical conditioning literature has been directed at the

effects of manipulating such variables as length of ITI (Prokasy, 1960, 1965; Papsdorf, Prokasy and Gormezano, 1964; Runquist and Muir, 1965), length of the ISI (Noble and Harding, 1963; Smith and Gormezano, 1965; McAdam, Knott and Chiorini, 1965) UCS intensity (Passey, 1948; Dykman and Grant, 1951; Spence, 1953; Gormezano and Moore, 1962), and CS intensity (Hull, 1952; Perkins, 1953; Logan, 1954). These parametric investigations have excluded the possibility of such potent control being brought to bear on classical conditioning by a variable of seemingly minor importance such as CAA.

Kettlewell and Papsdorf (1971) investigated the effects of attenuation of CAA from the orbital region of the eye on the development of the conditioned nictitating membrane response. Afferent activity was controlled by the use of a local anesthetic (0.5 percent tetracaine hydrochloride), varying the locus of the UCS delivery and applying mechanical tension on the eyelids. The results of the first of three experiments in the study indicate that animals acquiring the response under those conditions designated as high CAA, learn at a faster rate than those animals being trained under intermediate levels of CAA and that animals trained with low CAA do not appear to develop the response. A second experiment demonstrated that three different amounts of training under low CAA had no effect in improving the performance of these animals with respect to the performance of naive control animals when all animals were trained under high CAA conditions.

In a subsequent study, Kettlewell, Woolston and Berger (1972) sought to determine the effects of CAA on the performance of the

pre-established nictitating membrane response. In this study, animals were trained under high CAA to criterion and then the CAA levels for the various groups were manipulated. It was found that response levels appeared to be a direct function of the level of CAA under which the animal was performing. Another study (Kettlewell, Berger and Pezzino, 1973) showed that three different levels of CAA led to three different rates of extinction. The evidence is persuasive, therefore, that CAA is a potent variable in the manipulation of the acquisition of the conditioned nictitating membrane response, the performance of the pre-established response and the extinctions of the pre-established response.

In a later study (Kettlewell and Berger, personal communication, see appendix) the experimenters sought to simultaneously control the level of CAA for the eyes of the same animal in order to determine if performance in the two eyes of a single animal could be independently manipulated through the use of CAA techniques. Each subject (S) was initially trained with high CAA conditions in one eye and low CAA conditions in the other eye. After 10 days of simultaneous training with both eyes being monitored, the CAA conditions were reversed; the high CAA eye now performed under low conditions and vice versa. Two groups were run in order to counterbalance possible eye bias effects. The data from this experiment (also presented in the appendix) indicate that for Group 2 (high CAA in the left eye followed by low CAA in the left eye and low CAA in the right eye followed by high CAA in the right eye) response acquisition began immediately for the left

eye but was almost completely depressed in the right eye until after the change in conditions had taken place. For the purposes of this paper, this type of change in conditions shall be designated as crossover. The finding to be noted, however, is that the acquisition rate of the right eye after crossover is faster than the initial acquisition rate of the left eye. The same relationship holds true for Group 1 which was treated in an identical manner except for starting the initial conditions on the opposite eyes of the animals in the group. The result implies that while no learning is demonstrated by the right eye (low CAA initially) until crossover, some phenomenon analogous to latent learning has taken place as indicated by the accelerated post-crossover acquisition rate. Potentially, this apparent ability to exert unilateral control over the learning demonstrated by the nictitating membrane activity of the eyes of the rabbit presents the possibility of a preparation of considerable utility in the study of central transfer processes. In essence, by limiting learning to one side of the organism through the appropriate manipulation of CAA levels, one has created a behavioral analogue to classical split-brain surgical preparations (Sperry, 1967), without the incumbent technical difficulties.

It has been demonstrated (Kettlewell and Berger, 1973) that the level of CAA in the region of one eye has no effect on the rate of initial acquisition of the nictitating membrane response in the contralateral eye. Therefore, the different levels of CAA in each eye of the subjects in the bilateral conditioning paradigm cannot be the

direct cause of the differential acquisition rates observed. This study did not, however, test for possible latent learning, sensitization or a number of other possible effects and appears to be rather insensitive to learning effects from the contralateral eye. A latent learning paradigm is employed in the study presented here in order to provide a more sensitive analysis of the problem. There would appear to be a limited number of possible explanations for the accelerated post-crossover acquisition rate of the eye initially trained under low CAA.

The problem may be more directly phrased by asking exactly what is occurring during the initial training period of the animal which is operating under low CAA. Whatever process is taking place here is being reflected in the subsequent performance demonstrated by that eye. One possible process which could account for the findings would be sensitization. That is, no actual learning takes place under the initial low CAA conditions but the presentations of the CS and/or UCS are sufficient, regardless of their contiguity, to make the animal hyper-responsive. This augmented tendency to respond would be depressed by the low CAA conditions until crossover at which point an accelerated acquisition rate would be in evidence. This short exposure to the CS and UCS would be sufficient to account for the results observed in the bilateral conditioning experiment.

A second alternative concerns a mechanism that would permit some learning to occur. For Group 2, the left eye, which has low CAA initially, demonstrated no learning (as reflected in performance)

until crossover. It is possible that the CAA level in the left eye is sufficiently attenuated to depress all performance while allowing some learning to take place. The effects of this learning would, in turn, be seen after crossover when the higher level of CAA would allow high rates of responding. Learning according to this mechanism would be a result of a minimal level of CAA under the low CAA conditions, allowing some learning to take place.

The final possibility postulates no learning at all taking place in the left eye prior to crossover. Under this mechanism, the learned response in the right eye (initially high CAA) transfers to the other eye by means of some unspecified central nervous system process. Thus, training on one eye allows the animal to acquire the response in both eyes. The effects of this transferred learning would remain depressed by the low CAA conditions until after crossover.

There are three possible mechanisms, sensitization, minimal CAA, and central transfer which could account for the results obtained in the bilateral conditioning experiment. It is felt that these mechanisms, either individually or in some combination, exhaust the probable explanations of the latent learning observed in the double eye experiment. The purpose of the study here is to separate the effects of these three mechanisms and to determine the extent to which each of them contribute to the phenomenon in question.

CHAPTER II

GENERAL METHOD

Subjects

Thirty-six (36) experimentally naive New Zealand albino rabbits (Oryctologus cuniculus) of both sexes were used as subjects. They were approximately 2-3kg in weight during the period of the experiment. They were maintained on ad-lib food and water, in lighted, well ventilated, temperature controlled quarters. Six rabbits were randomly assigned to each of the six groups.

Techniques

Controlling levels of CAA in the orbital region of the eye is accomplished by several techniques. These involve anesthetizing the cornea and adjacent serous surfaces, exerting mechanical tension on the eyelids through the use of an eyeband, and the application of the shock UCS at different loci.

Corneal anesthesia is obtained by using a buffered, 0.5 percent solution of tetracaine hydrochloride. This is applied 15 seconds before the start of the session and produces anesthesia lasting approximately 15 minutes (Kettlewell and Papsdorf, 1971). The eyeband is a device consisting of an adjustable Velcro strap with tailor hooks sewn on each end. These hooks are inserted under the superior and inferior margins of the eyelids and the tension adjusted to produce lid separations.

approximately 50 percent greater than normal. Two loci of UCS delivery were used: the tip of the ear and caudal to the eye. At the tip of the ear, two nickel-silver, 11mm wound clips were implanted 3/8 to 1/2 inch apart. For the post-orbital locus, two wound clips were implanted 3/8 to 1/2 inch posterior to the temporal canthus of the eye.

Combining these techniques, several levels of CAA can be obtained. High CAA is presumed to occur using the post-orbital USC application, an eyeband and no anesthesia. The post-orbital application of the UCS leads to the activation of a greater number of cutaneous afferent fibers in the region of the eye than does UCS application to the tip of the ear. Thus, low CAA entails ear-shock, no eyeband, and corneal anesthetic. Under the low conditions, the afferent activity resulting from the eyeband is eliminated, as well as the activity resulting from the presentation of the UCS to the post-orbital position. Further, any other sources of afferent activity are at least partially eliminated by the anesthetic effects of the tetracaine hydrochloride.

Apparatus

A loop of thread was sewn through the nictitating membrane of each S and this loop was mechanically coupled to a photo-electric transducer mounted on the head of the animal by means of a muzzle-like assembly. Movements of the nictitating membrane resulted in voltage which were recorded on a Hewlett-Packard 141A storage oscilloscope using a 10cm/sec time base.

The CS was a 93-db SPL 1,000 Hz tone presented for 600 msec. The UCS, a 3-mA, 60 Hz electric shock was presented for 100 msec across wound clips placed at one of the two positions previously described. For paired trials, the UCS overlapped the last 100 msec of the CS presentation and the average intertrial interval was 60 sec for unpaired trials, the CS and UCS were presented at random intervals varying in duration from 40-80 seconds. No CS occurred within eight seconds of any UCS. The timing and control of the various events occurring within a session was accomplished with a BRS-Foringer digital logic. A daily session consisted of 15 CS-UCS presentations. Thus, for paired and unpaired trials, absolute exposure to tone and shock was identical; the temporal relationships being the only things that varied.

Preparation of the Ss began 48 hours prior to the first conditioning session. At this time a loop of 00 Ethicon silk suturing thread was tied into the nictitating membrane of the rabbit's eye. On the following day, the rabbits were placed in a plexiglas restraining box having an adjustable back-plate, head-yoke, and foam-padded ear clamp. They were then placed in the darkened, sound attenuating experimental chamber for 15 minutes to habituate them to the apparatus. All animals received daily corneal applications of either oxytetracycline ophthalmic ointment or neosporin ophthalmic ointment to retard infection.

Design

The phenomenon being investigated in this study was the rapid

acquisition observed in bilateral conditioning of the nictitating membrane under asymmetrical levels of CAA. The design for all groups was basically the same. There was an initial period of 10 days during which appropriate treatments were given to each group. After this period was ended, a new period was begun, called crossover, which was six days in length. During this period, all groups were trained under identical conditions and any effects resulting from the treatments in the initial period should be reflected in different performance during the crossover period.

The study was divided into three experiments. Each of these experiments was directed at one of the three previously discussed mechanisms (sensitization, minimal CAA, central transfer) which could conceivably account for the observed data.

Procedure

All animals were maintained in their home cages for at least 72 hours after being received from the supplier. This was done to allow the animals to become acclimated to the laboratory environment and procedures. At this point, a general preparation procedure was used for all Ss. The steps in this procedure are described below.

1. After the 72-hour waiting period, all animals had sutures placed in the nictitating membrane and had wound clips implanted for shock presentation.

2. On the following day, each S was given an habituation session. The apparatus was turned on and the S was placed in the restraining box and then placed in the experimental chamber but no presentations of the

CS or UCS were given. This allowed the Ss to become habituated to the apparatus.

3. On the day following habituation, the actual conditioning procedures were begun, using the previously mentioned conditioning parameters.

The CS, UCS, ITI and ISI are the same for all Ss but the procedures for manipulating CAA and the presence or absence of the parameters necessary for learning varied from group to group. These procedures are described later for each experiment.

Results

In the analysis of the data, the sum of CRs across the six days of crossover was used as a measure of the rate of acquisition of the response for each animal. An analysis of variance of the crossover performance of the six groups was done (Table 1). The F ratio ($F = 7.76$, $DR = 5/30$, $P < .05$) indicated the presence of significant group differences. At this point the comparisons relevant to the hypothesis of each experiment were made.

TABLE 1
Analysis of Variance
Groups 1-6

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Value
Between Treatments	5	11122.00	2224.40	7.76
Within Treatments	30	8604.00	286.00	
TOTAL	35	19726.00		

CHAPTER III

EXPERIMENT 1

Design

The first experiment sought to determine the relative effects that sensitization would have on the phenomenon in question. The basic element of sensitization lies exclusively in the effects of exposure to the CS and UCS. The conditions necessary for sensitization to occur are of course present any time an organism is classically conditioned, however, the effects of sensitization (i.e., any tendency toward hyperresponsivity) will be confounded by the learning which is taking place as a result of the contiguous pairing of the two stimuli. In order to control for learning effects, therefore, the occurrence of any conditioning in the sensitization group (Group I) was precluded by the use of unpaired presentations of the CS and USC. Since temporal contiguity is an essential component of the classical conditioning process, the possibility of learning has been eliminated but the conditions necessary for sensitization are still present. Therefore, the difference in crossover performance between the group trained under sensitization conditions (Group I) and a comparison group which had had exposure to the experimental apparatus but no exposure to CS or UCS (Group II) should indicate whether simple exposure to CS and UCS is an important contributor to the differential

acquisition in question. In order to control for possible effects of exposure to the experimental apparatus alone, Group II performance was compared to the performance of a group which received no treatment whatsoever for the 10 days prior to the crossover period (Group III).

Procedure

Group I

1. During the initial 10-day period, Group I (N = 6) received training on the right eye. Those conditions thought to produce high CAA were employed; shock delivery to the post-orbital position, use of the Velcro eyeband and the omission of any anesthetic from the area of the eye. Presentations of the CS and UCS were unpaired during the initial period.

2. During the six days of crossover, Group I received training on the left eye under high CAA conditions. Paired CS-UCS presentations were used during this period.

Group II

1. The treatment of Group II (N = 6) during the initial 10-day period was identical to that of Group I with the exception that CS and UCS were never presented.

2. Crossover treatment for Group II was identical to that given Group I.

Group III

1. For the 10 days of the initial period Ss in Group III were

maintained in their home cages. They were given no exposure to the apparatus, CS, or UCS.

2. Crossover treatment for Group III was identical to that given Group I.

Results

The results from Experiment 1 (Groups I, II, and III) are presented in Figure 1. A comparison of the crossover performance of Groups I and II was made using Scheffe's A Posteriori Test (Winer, 1972). The results ($F = 1.63$, $DF = 1/30$, $P > .05$, Critical $F = 10.70$) indicated that there was no detectable difference in the crossover performance of the two groups. The hypothesis that sensitization may contribute to improved crossover performance was not supported. A Scheffe's test comparing Group II performance with Group III performance also indicated no significant difference between the groups ($F = 1.76$, $DF = 1/30$, $P > .05$, Critical $F = 10.70$). This result indicates that there was no effect from simple exposure to the apparatus.

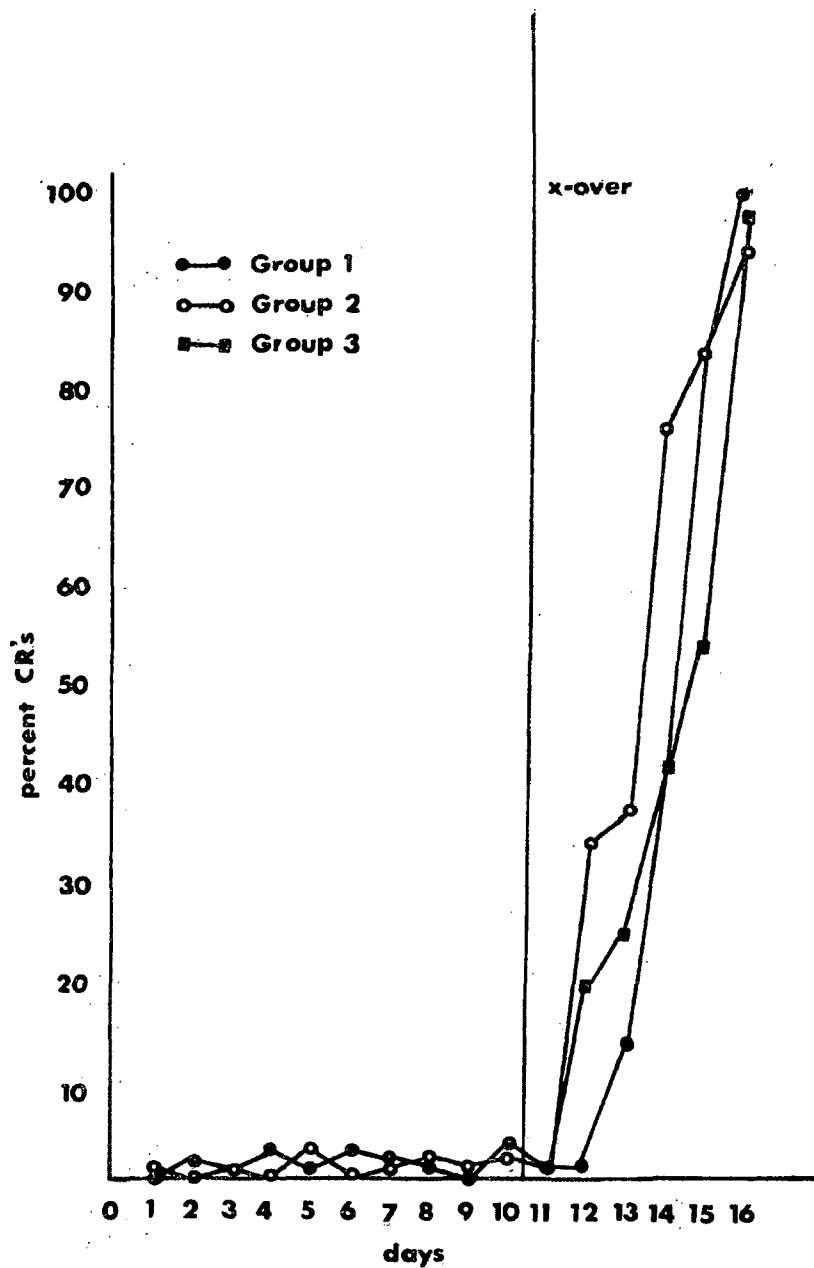


Figure 1. Performance curves showing Initial and Crossover periods. The vertical line indicates the onset of crossover conditions.

CHAPTER IV

EXPERIMENT 2

Design

A second mechanism which could account for the data in question is based on the possibility that the low CAA conditions used in the training before crossover in the bilateral conditioning experiment were sufficient to eliminate all performance of the conditioned nictitating membrane response but still allowed sufficient afferent activity from the region of the eye to permit some learning to occur. In order to answer this question, a group was run under low CAA conditions using paired trials (Group IV) and a group was run under low CAA using unpaired trials (Group V). Group IV was trained under all the conditions necessary for conditioning to occur except for the low level of CAA. Group V, on the other hand, could demonstrate no conditioning because of the use of unpaired CS and UCS presentations. Groups IV and V were equated for possible sensitization effects as well as for CAA level. If learning occurred under low CAA the effects of this learning should be seen as a difference in the crossover performance of Groups IV and V.

Procedure

Group IV

1. Group IV was trained for the initial period on the left eye using low CAA conditions. These are defined as shock delivery to the

tip of the ear on the side of the animal being conditioned, use of 0.5 percent tetracaine as an anesthetic applied to the cornea and adjacent serous surfaces, and the omission of the eyeband. Group IV received paired presentations of CS and UCS during this period.

2. Crossover training for Group IV was identical to that given Group I.

Group V

1. The initial period treatment for Group V was identical to that given to Group IV except that CS-UCS presentations were unpaired.

2. Crossover treatment for Group V was identical to that given Group I.

Results

The results from Experiment 2 (Groups IV and V) are presented in Figure 2. A comparison was made using Scheffe's test between the crossover performance of the two groups. The results of this comparison ($F = 5.29$, $DF = 1/30$, $P > .05$, Critical $F = 10.70$) show no difference between the groups and lend no support to the hypothesis that minimal CAA allows latent learning to occur under low CAA conditions.

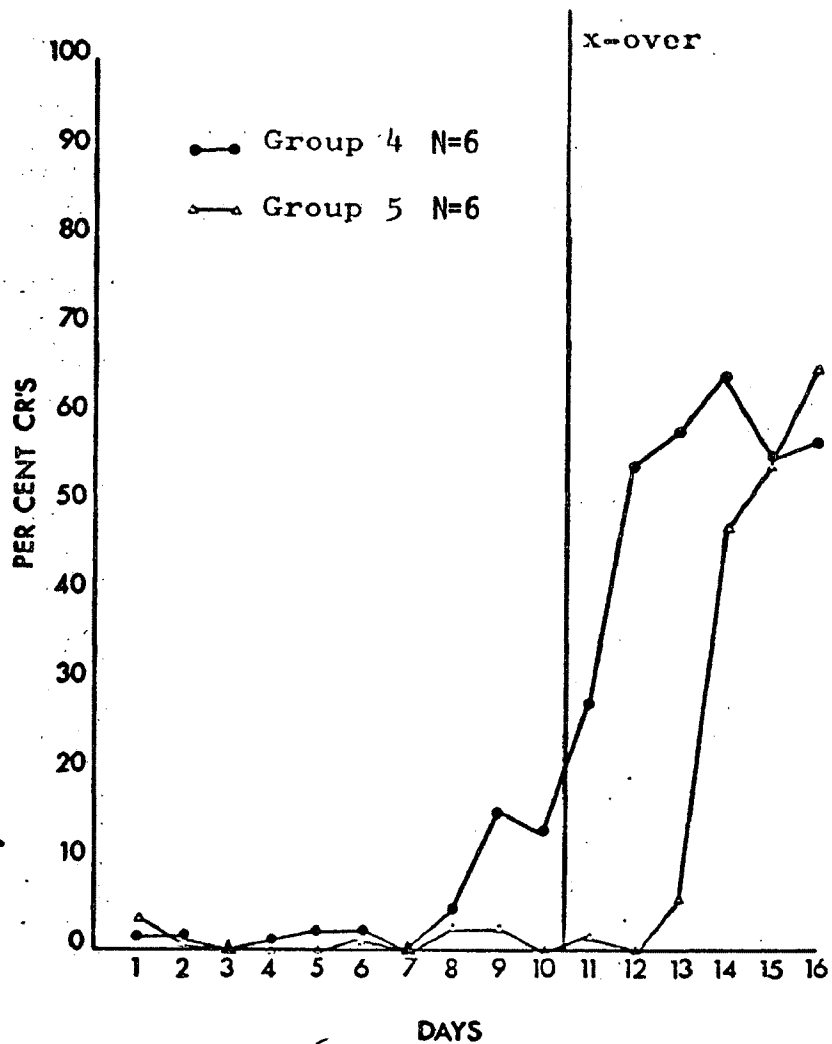


Figure 2. Performance curves showing Initial and Crossover periods. The vertical line indicates the onset of crossover conditions.

CHAPTER V

EXPERIMENT 3

Design

The final possibility considered in this experiment was that of central transfer. That is, the effects of learning taking place in the high CAA eye are evident in the crossover performance of the low CAA eye because of the operation of a central nervous system transfer mechanism. The performance of two groups was compared. One group was trained under high CAA on one eye during the initial period (Group VI) and then trained under identical CAA conditions on the other eye. The comparison group received training on one eye under high CAA but unpaired trials were used (Group I). In the paired trials groups, therefore, learning and central transfer may occur while in the unpaired trials group no learning and no central transfer may occur. The two groups were equated for CAA level and for possible sensitization effects.

Procedure

Group VI

1. Group VI was trained on the right eye under high CAA conditions during the initial period. Paired presentations were used.
2. Crossover treatment for Group VI was identical to that given Group I.

Group I

The procedures for Group I have previously been described.

Results

The results of Experiment 3 (Groups VI and I) are presented in Figure 3. The Scheffe's test between the crossover performance of these two groups indicates a significant difference between them ($F = 21.3$, $DF = 1.30$, $P < .05$, Critical $F = 10.70$). This difference offers rather clear support for the hypothesis that some central transfer process is in fact in operation in the bilateral conditioning situation.

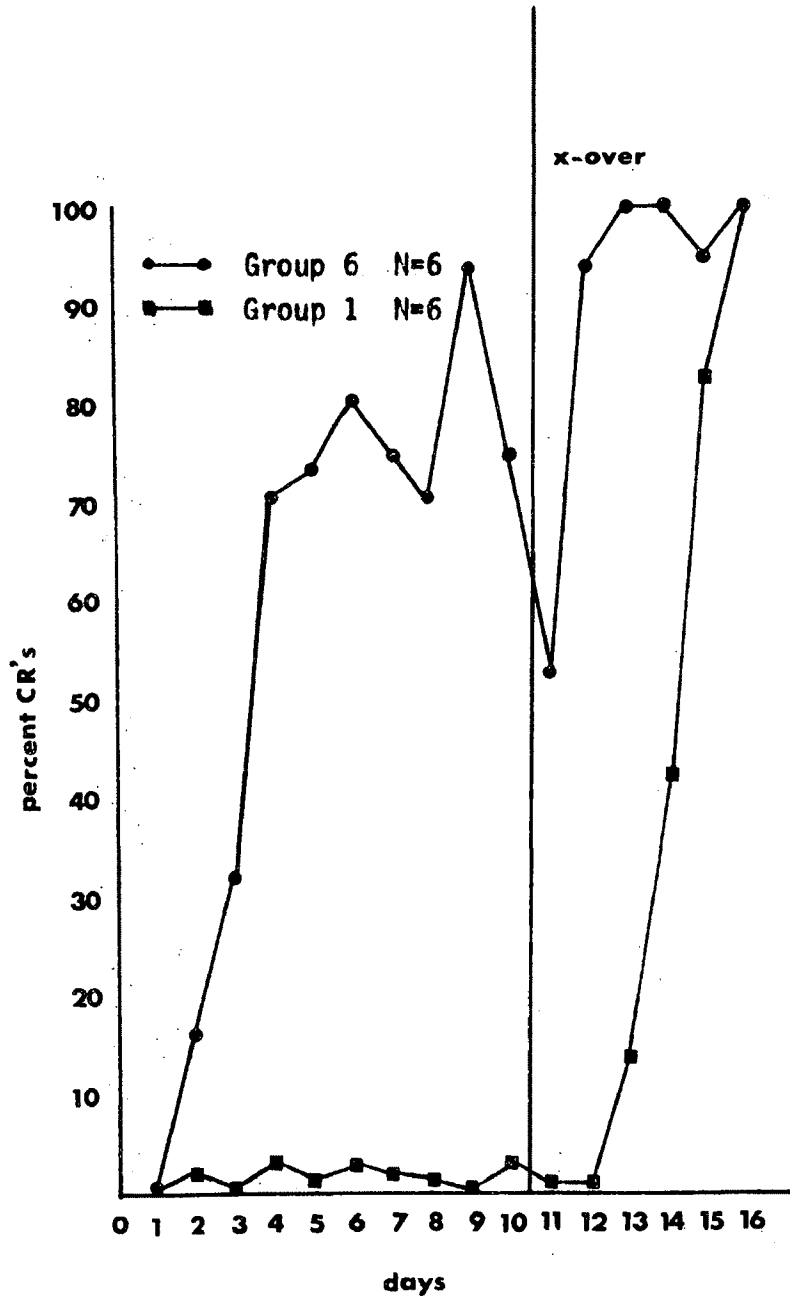


Figure 3. Performance curves showing Initial and Crossover periods. The vertical line indicates the onset of crossover conditions.

CHAPTER VI

DISCUSSION

Examination of the figures representing the results indicates rather clearly the conclusions that can be drawn from this series of experiments. Figure 1 shows no difference between groups I, II, and III. This lack of difference implies that sensitization is not a contributing variable as far as the results of the bilateral conditioning experiment are concerned. Figure 2 represents the results of the experiment involving Groups IV and V. In this case also there are no significant differences between the groups. This result allows the rejection of the hypothesis that minimal levels of CAA present during conditioning may be sufficient to allow conditioning to occur. The lack of difference between Groups IV and V shows that whatever learning may occur under minimal CAA conditions is of insufficient magnitude to account for the results of the bilateral conditioning experiment.

Figure 3, showing the performance of Groups I and VI, indicates a clear difference between the performance of the two groups after crossover. It can be concluded that these crossover differences between VI and I are a result of their respective treatments during the initial segment of the experiment. These treatments included presentation of classical conditioning trials to the right eye of the

Group VI animals and presentation of unpaired trials to the right eye of the Group I animals. Since all other conditions remained constant across the groups, the learning demonstrated in the right eye of the Group VI animals would appear to account for the crossover differences between the groups. Learning in this situation, therefore, is not unilateral and classical conditioning obtained on one eye of the organism is transferred with relatively little loss to the other eye. The operation of a central transfer mechanism would seem to be indicated by the data.

Initial examination of the data from the bilateral conditioning experiment would seem to indicate that manipulation of CAA levels on the two eyes of the animal allows corresponding manipulation of the levels of classical conditioning which are taking place. The initial implication of this finding relates to the possibility of a preparation for use in learning paradigms which could be a functional analogue to Sperry's split-brain. The findings of the present series of experiments, however, indicate that central transfer occurring within the subject eliminates the possibility of unilateral classical conditioning in the rabbit using low CAA levels in the untrained eye to depress conditioning.

CHAPTER VII

SUMMARY

The study was designed to determine which of three possible mechanisms would account for the latent-learning type of performance effects observed when both eyes of a rabbit are simultaneously conditioned under different levels of cutaneous afferent activity. Of the three mechanisms investigated, sensitization, minimal CAA and central nervous system transfer, the results strongly support the interpretation that central transfer of the classically conditioned response accounts for the phenomenon seen in the bilateral conditioning paradigm.

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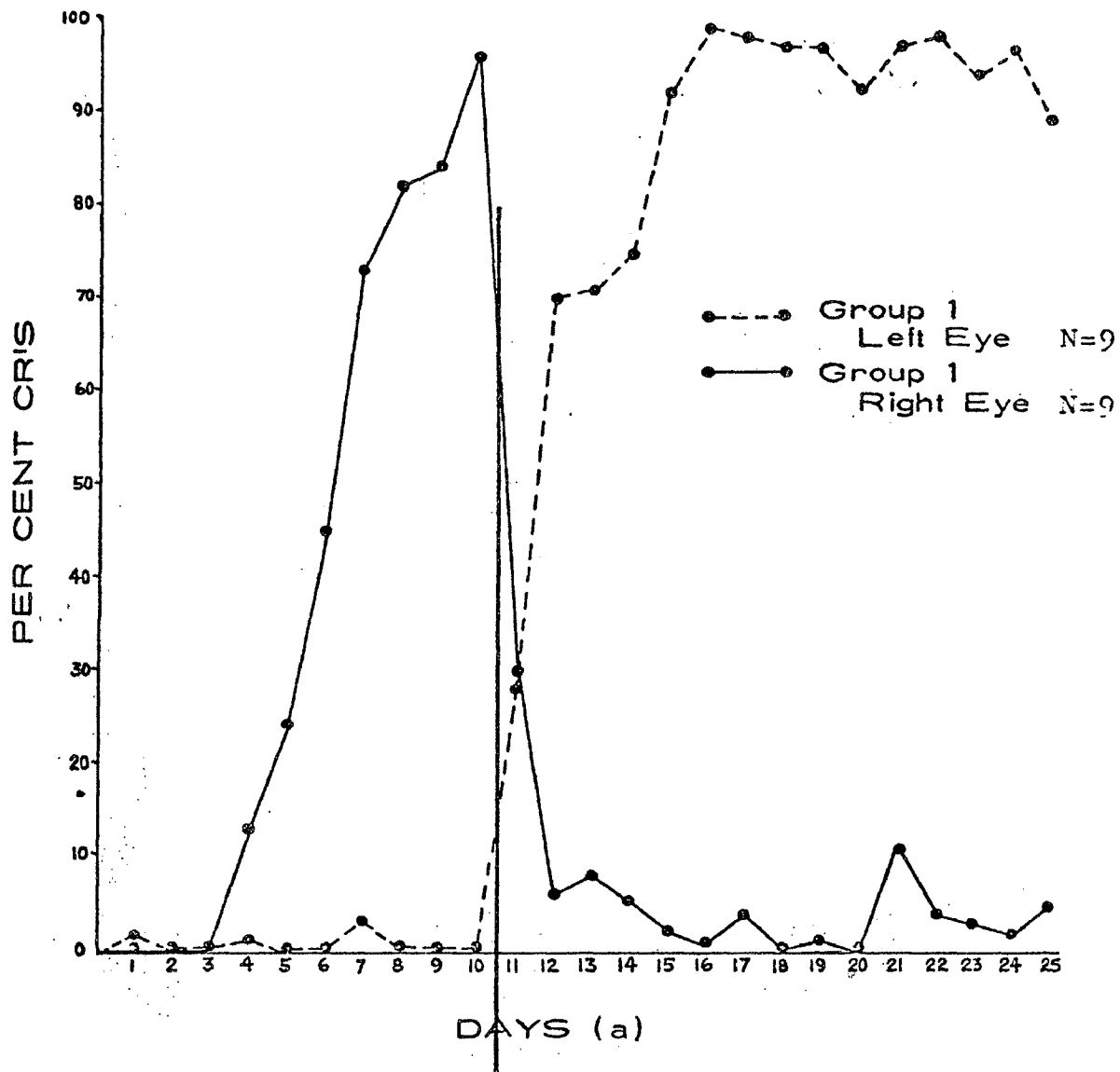
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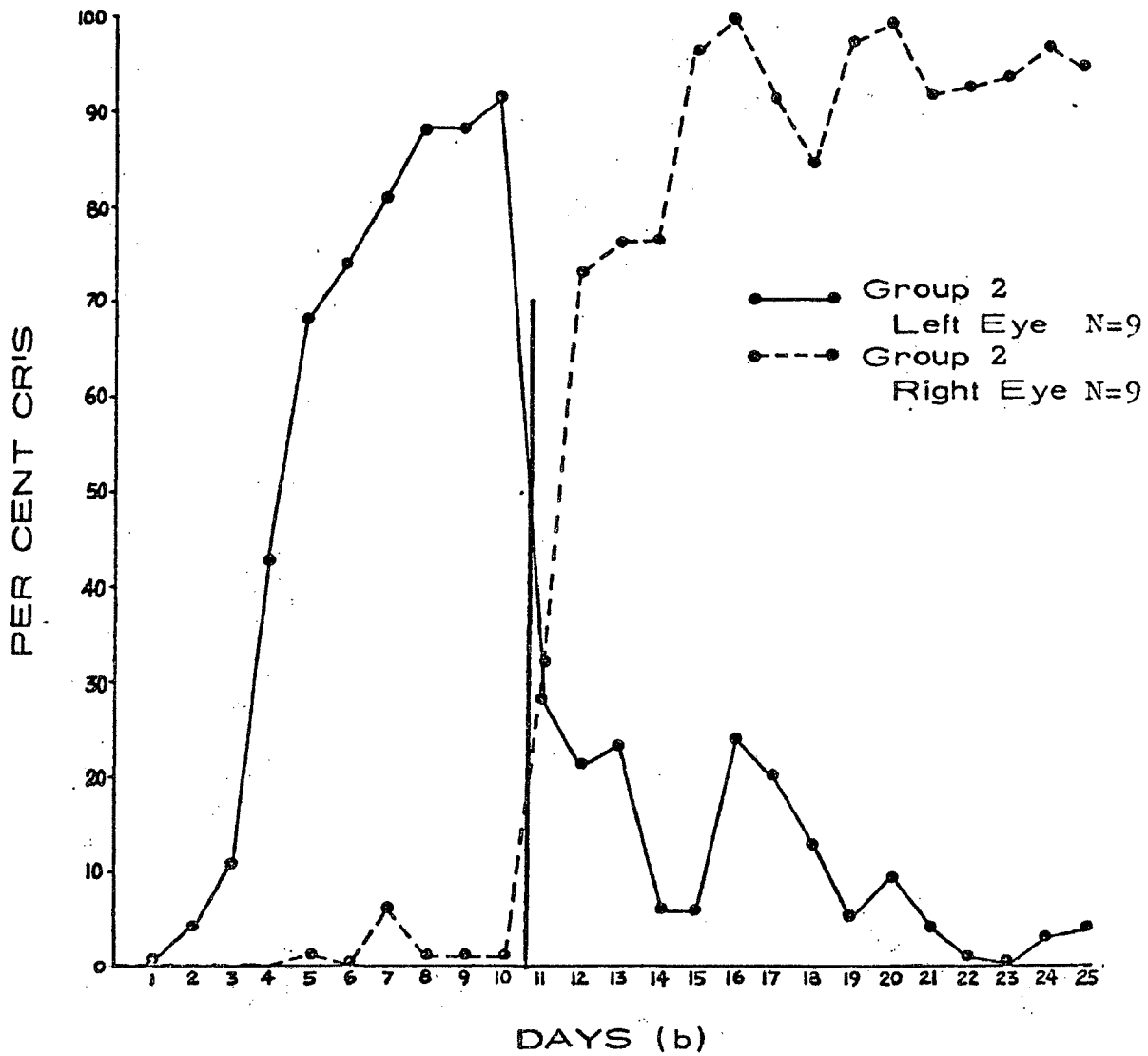
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APPENDIX 1



Results for Group I of the bilateral conditioning experiment. Vertical line indicates crossover. Conditions for the left eye were low CAA before crossover and high CAA after crossover. Conditions for the right eye were high CAA before crossover and low CAA after crossover. (from Kettlewell & Berger, personal communication)



Results for Group 2 of the bilateral conditioning experiment. Vertical line indicates crossover. Conditions for the left eye were high CAA before crossover and low CAA after crossover. Conditions for the right eye were high CAA before crossover and low CAA after crossover. (from Kettlewell & Berger, personal communication)