

EFFECT OF DISCRIMINATIVE PAVLOVIAN FEAR CONDITIONING
ON SUBSEQUENT DISCRIMINATIVE AVOIDANCE ACQUISITION
IN THE GOLDFISH (CARASSIUS AURATUS)

A Thesis
Presented to
the Faculty of the Department of Psychology
University of Houston

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Dorothy Lam Wong
August, 1972

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ABSTRACT

180 goldfish were given discriminative Pavlovian fear conditioning to red and green colors and tested for transfer of training with reinforced discriminative avoidance acquisition tasks involving different combinations of red, green, and yellow colors. Mass conditioning was employed in all cases. Results indicated that:

- 1) Fish had a strong color preference hierarchy of green > yellow > red which was not altered by fear pretraining.
- 2) Prior fear conditioning affected subsequent avoidance acquisition in the expected direction and relatively permanently. Consistent discriminative transfer groups performed significantly better than inconsistent discriminative transfer groups. However, neither were significantly different from control.
- 3) Control performances tended to be worse than both experimental performances on Day 1 and fluctuated erratically overlapping both experimental groups thereafter.
- 4) There were indications that experimental Ss did not merely learn " $CS^+ \rightarrow CS^-$ " as a unit, but were able to avoid CS^+ to any other color, and approach CS^- from any other color. This latter ability also meant that CS^- had become affectively positive for the Ss.

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CHAPTER I

INTRODUCTION AND HISTORY

Conception of the Two Factor Theory of Learning

Mowrer (1951) charged with being teleological the conventional explanation of instrumental conditioning that a response is strengthened or weakened by virtue of its consequences. He further charged that monistic theories of learning such as Thorndike's "Law of Effect" and Hull's "Theory of Reinforcement" were ill equipped to explain one-trial avoidance learning tasks where the animals learn to perform the required response without experiencing much of the aversive stimuli.

To resolve this conflict, Mowrer (1946, 1947, 1951, 1960) proposed the Two Factor Theory of Learning. In essence, he claimed that there are two separate and distinct types of learning (sign learning and solution learning) involved in any instrumental conditioning situation. This is true regardless of whether the instrumental conditioning situation is appetitive or aversive.

1) Sign learning. This precedes solution learning and is a process whereby emotions, attitudes, meanings, and cognitions are acquired. Sign learning involves

stimulus substitution, associative shifting (Thorndike) and is essentially what is better known as Pavlovian classical conditioning. Physiologically, sign learning involves the autonomic nervous system, involuntary systems and viscerovascular reactions.

2) Solution learning. This is better known as instrumental conditioning and is the process whereby overt instrumental habits are formed. Physiologically, solution learning involves the skeletal musculature and voluntary systems. It is also a process of response substitution.

Sign learning exerts profound control over solution learning. The conditioned emotional response (CER) established during sign learning has secondary drive properties. It is the reduction of this drive which maintains the instrumental response subsequently established during solution learning.

With this, Mowrer claimed to have overcome the criticism of teleology in explaining the acquisition and maintenance of instrumental responses.

The Two Factor Theory of Avoidance Learning

The Two Factor Theory of instrumental learning initiated work in the specific area of avoidance learning (Brown and Jacobs, 1949; Konorski, 1948; Miller, 1944, 1948, 1951; Rescorla and Solomon, 1967; Solomon and Wynne, 1953). The present study also falls within the confines of this area.

Avoidance learning is said to consist of two phases.

Phase I involves Pavlovian fear conditioning to the CS. Fear is a learned, anticipatory response to painful stimuli. It has secondary motivational properties, and its reduction is said to be reinforcing (Miller, 1948; Brown and Jacobs, 1949).

Phase II is the actual acquisition of the instrumental avoidance response. The animal initially escapes the shock to reduce accompanying pain. When the acquired fear of the CS in phase I has reached a high enough level, the animal now avoids the shock on signal in order to reduce fear. Thus, it is the reduction of fear which maintains the avoidance response (Solomon and Wynne, 1953).

Transfer of Training

Since two separate processes are evidently involved in avoidance learning, and since phase I has such control over phase II, it follows that prior Pavlovian fear conditioning should facilitate subsequent acquisition of an instrumental avoidance response. Studies examining this relationship are called Transfer of Training studies.

The typical paradigm is outlined by Brown and Jacobs (1949) and many others. It entails a Pavlovian fear conditioning phase during which a neutral stimulus is consistently followed by inescapable shock. Testing consists of non-reinforced instrumental avoidance training trials

utilizing the same conditioned stimulus. Transfer or facilitation is said to have occurred if the experimental group makes significantly more escapes to the CS than the control group which has received no prior fear conditioning. Many variations of the basic paradigm have been employed.

Such transfer of training studies from classical to instrumental conditioning have been of varying success. Before analyzing the factors contributing to the success or failure of these studies, a brief examination of the proposed mediational processes involved is in order.

Mediational Processes in Transfer of Training

All proposed mediational processes of training transfer fall into two broad categories--those that employ central mechanisms, and those that employ peripheral mechanisms.

I. Central mechanisms. This category is championed by the cognitive theorists. These go by their dictum: "Given knowledge, behavior will take care of itself." The argument is that some process very closely akin to latent learning takes place during the Pavlovian conditioning phase. Birch and Bitterman (1951, 1949) call the process sensory integration. It is this learned knowledge that carries over to the avoidance phase.

Thus far, the proof of this theory lies chiefly in the successive elimination of competing theories. For

example, Seidel (1958) claims that curare studies have effectively ruled out the skeletal mediation theory, and cross-drive studies have effectively ruled out the autonomic mediation theory leaving only the cognitive theory as the most viable one.

II. Peripheral mechanisms. This is further divided into two subcategories: Skeletal mediation theory, and autonomic state mediation theory.

a) Skeletal mediation

Proponents of this theory argue that the instrumental responses of activity, running, and jumping are superstitiously or inadvertently conditioned to the CS during the classical conditioning phase. If such skeletal responses are called for in the subsequent avoidance task, then facilitation would result. Studies have been done (Mullin and Morgenson, 1963; Weiss, Kriekhaus and Conte, 1968) where researchers have found a positive correlation between preshock activity in animals and subsequent avoidance success.

On the other hand, Leaf (1964), Solomon and Turner (1962) and other researchers have found that transfer occurs even when the animals are curarized during the Pavlovian phase. The question still remains, however, as to whether curare effectively blocks all skeletal responses.

b) Autonomic state, emotions, and secondary motivations

This theory seems to have by far the most supporters. As stated above, Mowrer (1946, 1947, 1951, 1960), Miller (1944, 1948, 1951), Brown and Jacobs (1949), Solomon and Wynne (1953) all feel that the mediator in avoidance transfer of training studies is the acquired drive fear. This fear is probably manifested as an autonomic nervous system state, a pattern of diffuse stimuli which acts as the link between the two conditioning situations.

Researchers dealing with appetitive transfer of training studies (Bower and Brusec, 1964; Seward, 1950; Spence, 1956) also propose an autonomic state as the possible mediator. In appetitive studies, the Pavlovian phase consists of pairing a neutral stimulus with food or water. Later, the animal is made to learn an instrumental task signalled by the same CS in order to obtain reinforcement. Positive transfer is said to have occurred if the animal learns the subsequent task faster than a control which has had no prior experience with the CS. In the appetitive case, the acquired state would be one of "expectation" or "hope".

To date, the issue of which is the correct theory has yet to be definitively resolved. It may be that any one of the proposed mediation mechanisms may contribute to the transfer, but no one single mechanism has yet been found to

be indispensable. Since it is not the purpose of this paper to resolve the dispute, nothing further will be said on the topic.

It is however, the intent of the present study to demonstrate transfer of training in an avoidance situation. Hence, a detailed review of the factors affecting such a transfer is in order.

Factors Affecting Transfer of Training

According to Mowrer's Two Process Theory of Avoidance learning (1951), the prior administration of fear conditioning in avoidance transfer of training studies should result in the facilitation of subsequent avoidance acquisition. In practice, however, such studies have yielded conflicting results ranging from the expected facilitation, to no effect, and even to interference with subsequent avoidance acquisition, a phenomenon similar to Maier, Seligman and Solomon's "Learned Helplessness" (1968).

An analysis of all the studies indicates that whether a study is successful or unsuccessful in demonstrating facilitation of avoidance acquisition depends on a multiplicity of factors or experimental manipulations. 1) Amount of prior fear conditioning; 2) Nature of shock; 3) Signalled versus unsignalled shock; 4) Adaptation to shock; 5) CS-US interval in avoidance and classical conditioning phases; 6) Competing responses developed during classical conditioning

phase; 7) Ease of avoidance task; 8) Post conditioning delay interval.

These factors seem to be additive in function and highly interrelated with each other.

1) Amount of prior fear conditioning--Intensity of shock and number of shocks.

McAllister and McAllister (1962) found by varying shock levels during Pavlovian fear conditioning that increase in shock intensity leads to increase in transfer of training to a subsequent instrumental task. The highest voltage employed was 100 volts and subjects were rats. They attributed this facilitation to an increase in fear which resulted from the high shock intensities.

Kalish (1954) established also that fear increases as a monotonic function of the number of conditioning trials. It appears then, that high shock intensities and greater number of fear conditioning trials give rise to increased fear in subjects which in turn betters transfer of training.

Yerkes and Dodson's work (1908) on the inverted U-shape function of the relationship between fear and performance must be borne in mind at this point. It may be that at extremely high shock levels, and with a great number of conditioning trials, fear would have increased to such a degree that performance would actually be hindered. Thus far, most of the successful transfer of training studies have not employed inordinately high shock intensities or great number

of fear conditioning trials.

2) Nature of shock: - Shock duration, pulsed shock versus long steady shock, shock density.

The general finding in this area is that short pulsed shocks as opposed to long steady shock administered during the Pavlovian fear conditioning phase lead to better facilitation of subsequent instrumental response acquisition (Baum, 1969; Brown and Jacobs, 1949; Dinsmoor, 1958).

Both Dinsmoor (1958) and Brown and Jacobs (1949) feel that with pulsed shocks, the animals are given less opportunity to develop such competing responses as crouching, freezing and withdrawal which may hinder the desired instrumental response. With a long steady shock however, animals are more prone to freeze.

Baum (1958) on the other hand feels that short pulsed shocks lead to better facilitation because fear is more firmly established under those conditions.

The parameter of shock density was explored by Overmeir and Seligman (1967). Although their results show "learned helplessness" rather than facilitation as specified by the Two Factor theory, they did find that shock density does make a difference. Higher shock densities resulted in greater interference and vice versa.

3) Signalled versus unsignalled shock

It appears that in order for the transfer effect to

occur, prior fear conditioning must be differentially paired with stimuli which would occur in the avoidance situation. In cases where the fear conditioning is unsignalled, some features of the apparatus must act as the conditioned stimulus to the fear, and also these features must be present during the avoidance phase to serve as a link.

de Toledo and Black (1967) demonstrated the above stipulation by administering fear conditioning to a group of rats in an apparatus other than the avoidance box and without a signal. They found that the rats did not show facilitation when tested immediately as opposed to a group of rats which had been given fear conditioning in the avoidance apparatus. They further suggested that for optimum transfer results, there should be a safe signal and a danger signal (differential conditioning) during fear conditioning rather than just a danger signal.

That signalled shock yields superior transfer results is also evident in studies such as Overmeir and Seligman's (1967) where unsignalled shock gives rise to learned helplessness.

4) Adaptation to shock

There is a great deal of debate over this issue. Some researchers (MacDonald, 1946) feel that the reason for no "transfer of training effect" or "interference effect" during the avoidance phase is because the animal has adapted to

the shock. Other experimenters show that this is not so by obtaining "interference" even when the shock level is raised during the avoidance phase (Overmeir and Seligman, 1967).

5) CS-US interval in avoidance and classical conditioning phases.

For the classical conditioning phase, delay conditioning is found to be superior to trace conditioning. Also, except when the CS-US interval is zero in which case there is no conditioning, the optimum interval is quite flexible. The ISI seems to affect only the initial latency of avoidance response but not the magnitude (Bitterman, 1964; Brookshire and Frumkin, 1969).

For the avoidance conditioning phase however, it seems that a long CS-US interval is desirable (Miller, 1948; Brookshire and Frumkin, 1969). A long ISI here allows any inadvertently conditioned competing response to work its way out and dissipate, making way for the desired response. Brookshire and Frumkin (1969) find that an ISI of 30 seconds is optimal for avoidance in fish.

The remaining factors to be discussed are of greater importance and hence will be presented in detail.

6) Competing responses developed during classical conditioning phase.

It has been established earlier in the paper that skeletal responses conditioned during the Pavlovian fear conditioning phase cannot be the sole mediators of transfer of training. However, this does not preclude the possibility that inadvertently or superstitiously conditioned skeletal responses to the fear eliciting CS may well show up during the avoidance acquisition phase and act to hinder the facilitation of avoidance acquisition.

Mullin and Morgenson (1963), Dinsmoor and Campbell (1956), and McAllister and McAllister (1962) all find that if the superstitiously learned skeletal responses are relevant to the avoidance task, there will be facilitation. However, if the learned skeletal responses are crouching, freezing, and withdrawal, then there will be interference with avoidance acquisition.

Whether an animal freezes or becomes more active when shocked depends on several variables. The nature of the shock (short pulsed versus long steady) is one that has already been discussed. Another important variable is species differences in reactions to shock. Anisman and Waller (1971) did a study comparing transfer of training in two strains of rats: the Holtzman and the Sasco. They found that the more active Holtzman strain acquired the avoidance responses considerably faster than the relatively less active Sasco strain. A third variable concerns whether

the animal is a good learner or poor learner. Pinckney (1967), working with fish, found that the poor learners were responsible for his failure to obtain transfer of training. These animals tended to freeze more.

At any rate, it does seem that preshock activity and the subject's reaction to shock are good indices of whether facilitation or interference would occur (Weiss, Kriekhaus and Conte, 1968; Anisman and Waller, 1971).

It stands to reason from the above discussion that skeletal musculature paralysis drugs such as curare and chlorotone should eliminate development of competing skeletal responses and thus facilitate transfer of training. This has been shown to be so by Leaf (1964), and Solomon and Turner (1962) using curare on dogs. Anderson (1967) using chlorotone on fish also reports partial success.

Finally, the element of fatigue may also be grouped under competing responses. In studies where a great number of fear conditioning trials are administered followed immediately by testing, fatigue and physical debilitation may have a big hand in causing interference of avoidance acquisition.

7) Ease of avoidance task

One important factor which influences the possibility of transfer of training from classical conditioning to an operant task is the ease or prepotency of the operant task

in the animal's hierarchy. The more inaccessible the response is to the animal, the less are the chances of transfer.

Theoïs and Dunaway (1964) showed that one-way avoidance tasks are easier to learn than two-way shuttles. In examining the successful transfer of training studies, one finds indeed that the predominantly used tasks are the one-way avoidance tasks or similar easy tasks such as ledge jumping (Anisman and Waller, 1971; Baum, 1969; Frumkin and Brookshire, 1969; Brookshire and Hognander, 1968; deToledo and Black, 1960). Experimenters who employed difficult tasks often had negative results (Mullin and Morgenson, 1963).

The rationale for success in using easy tasks is that the desired response would be more prepotent in the animal's hierarchy and hence there is less opportunity for any competing responses to take over.

Many experimenters who do use relatively more difficult tasks find that pretraining on the instrumental response prior to fear conditioning would make the response more prepotent and hence contribute to transfer of training (Weiss, Kriekhaus and Conte, 1968; and Baum, 1969). In fact, Rescorla and Lolordo (1965) even resort to the novel procedure of alternating classical fear conditioning with operant response training prior to testing for transfer.

8) Post conditioning delay

A final factor affecting the outcome of transfer of

training studies is the post-conditioning delay interval (PCDI) between Pavlovian fear conditioning and operant response testing.

As it is stated by Mowrer (1951), the Two Factor Theory of avoidance learning makes no specifications about a post-conditioning delay interval. It is however, the general consensus of the researchers in this area that the PCDI does play a role, and that there is a critical interval after fear conditioning within which no transfer would be evident. Furthermore, this critical interval seems to be different for different species. McAllister and McAllister (1962, 1964) have established that for rats a post-conditioning delay of 24 hours is sufficient, and transfer would occur after that. Overmeir and Seligman (1967) find that the optimum delay for dogs is 48 hours, and Pinckney (1966) claims that for fish, a delay of greater than 24 hours is necessary.

What these researchers do not agree upon is the question of why the delay? What happens during this period?

Bindra and Cameron (1953) postulate an incubation of fear explanation. They claim that anxiety associated with specific cues tend to increase in intensity as a function of time. The delay is probably necessary for the fear to reach a critical level.

Frumkin and Brookshire (1969) on the other hand say that the delay is necessary for the fatigue, competing

responses and debilitation resulting from conditioning to dissipate.

Pinckney (1966) and Brush, Myer and Palmer (1963), explain that a hindering generalized emotional state is present or builds up right after Pavlovian conditioning. This parasympathetic overreaction has to be allowed to subside with time before transfer could occur.

The final hypothesis and perhaps the most viable one makes use of the finding that fear increases to generalized stimuli with time (Perkins and Weyant, 1958). McAllister and McAllister (1964) demonstrates this quite convincingly by administering fear conditioning to subjects in same and different boxes compared to the original avoidance box, and testing immediately and after a 24 hour delay. They found that for subjects trained in the different box and tested immediately, no transfer was evident. However, subjects trained in the different box and tested after a 24 hour delay showed transfer of training. This benefit of the delay was not very evident for subjects trained and tested in the same apparatus. They conclude therefore that with time, the stimulus generalization curve for fear flattens, and the subjects would respond to a generalized stimulus. With no delay, the fear is not great enough for discrimination to break down. A pure incubation of fear hypothesis such as Bindra and Cameron's (1953) would not be tenable since the

subjects trained and tested in the same box did not show improvement with delay.

Such are the ingredients for a successful transfer of training study from classical fear conditioning to instrumental avoidance learning. Again, the importance of species differences and interrelationships of all these factors cannot be overemphasized.

CHAPTER II

STATEMENT OF PURPOSE

The goals of the present study are as follows:

1) To observe the transfer of training from discriminative classical fear conditioning to discriminative operant avoidance shuttling in goldfish (carassius auratus).

Such discriminative transfer studies have been done but only in appetitive paradigms involving rats. Bower and Grusec (1964) did a study in which they paired CS^+ with water and CS^- with no water during the classical conditioning phase for water deprived rats. They tested for training transfer under two conditions, a consistent discriminative transfer condition in which CS^+ now signalled bar press for water ($CS^+ = CS^D$, $CS^- = CS^A$), and an inconsistent discriminative transfer situation in which CS^- previously associated with no water now signalled bar press for water ($CS^+ = CS^A$, $CS^- = CS^D$). Results showed that the consistent transfer group had uniform advantage over the inconsistent group in acquiring the bar press response.

Mellgren and Ost (1969) repeated the above experiment adding a control group. They were able to show that the

difference between the consistent and inconsistent groups was due to the depressed performance of the inconsistent group and not to the facilitated performance of the consistent group.

The present study utilizes an adaptation of the above procedures for avoidance transfer of training in goldfish.

During the discriminative Pavlovian fear conditioning phase, a CS^+ (color light) will always be followed by shock whereas a CS^- (a different color light) will be explicitly paired with no shock. In the avoidance phase, a consistent group will be made to shuttle from CS^+ (now CS^D) to CS^- (now CS^A), and an inconsistent group will be made to shuttle from CS^- (now CS^D) to CS^+ (now CS^A). Control groups which have received no prior fear conditioning will be run as comparisons. Results will be analyzed in terms of whether the consistent group performs better than the inconsistent group, and whether this difference is due to facilitation of the consistent group or inhibition of the inconsistent group as compared to the control.

2) If prior differential fear conditioning has the expected influence on both the consistent and inconsistent tasks, the following step would be to see if the learning transferred is a very specific phenomenon. In other words, does the fish learn specifically to avoid the CS^+ and approach the CS^- as a unit, or could it avoid the CS^+ to

any color and approach the CS^- from any other color.

In the same vein, it would be interesting to see if this learning would show up as interference in partially inconsistent tasks which involve having the subject shuttle from a neutral color to a previously shocked color CS^+ , and from a previously safe color CS^- to a neutral color.

By examining the issue of whether the experimental Ss could learn to approach the CS^- from a neutral color faster than the control Ss, the issue of whether the CS^- used during classical conditioning has acquired positive affective associations for the Ss or whether it has remained neutral with respect to other colors is also resolved. Again, one would expect that if the CS^- has indeed become positive affectively, the acquisition of an avoidance task which involves shuttling from a neutral color to the CS^- should be easier for the experimental group with which the CS^- had previously signalled safety. Conversely, the same experimental group should show interference of avoidance acquisition in a task which requires shuttling from the previously safe CS^- to a neutral color.

3) As a side product of this study, an establishment of some sort of color preference hierarchy in fish would be possible by observing the differential learning rates of the control fish in avoidance tasks which involve different color combinations.

Zippel and Domagk (1969) from Germany have made several passing remarks in their works to the effect that it is common knowledge throughout Europe that goldfish have a pre-experimental preference for red. Galvan (1971) on the other hand, has found that the opposite is true for American goldfish. The latter seem to have a preference hierarchy of green, then blue, and least of all red.

4) One final goal would be to see if prior Pavlovian fear conditioning to different colors would be of sufficient potency to bring about a change in the pre-experimental color preference hierarchy in fish as reflected by differential avoidance acquisition rates.

If, for example, fish have a pre-experimental aversion to red, then learning a red to green shuttle task would be much easier than learning a green to red one. An experimental group preshocked in green may learn the green to red shuttle faster than a non-preshocked control group. However, this facilitated rate of green to red acquisition may still be lower than the control red to green acquisition rate. Should this be the case, then while it is possible for prior fear conditioning to facilitate subsequent avoidance acquisition, the basic color preference hierarchy has still remained unchanged.

CHAPTER III

METHODS AND PROCEDURES

Subjects

The subjects were 180 3-4" goldfish (carassius auratus, common comets) from Ozark Fisheries, Stoutland Missouri. Ss were housed in several 40 gallon tanks at the University of Houston laboratories for at least one week after arrival. Four days before the start of the experiment, Ss were transferred to 3 gallon white dish pans, 5 Ss to a pan, which served as home tanks for the entirety of the experiment. Water was changed every two days with the appropriate precautions taken for dechlorination. Ss were fed two pellets each of commercially available goldfish food every other day after the start of the experiment.

Apparatus

Two different experimental boxes were used in this study, one for the classical fear conditioning phase, and another for the operant avoidance acquisition phase.

The apparatus for classical fear conditioning consisted of a 20 gallon tank, 76.5 cm. x 33.5 cm. x 31.5 cm. with the sides of the tank blackened. The level of water used was

constantly 12.5 cm. A black plexiglas lid was fitted with 2 sets of 3 same-colored 25 watt light bulbs, green and red. The two parallel long walls of the tank were fitted with aluminum mesh electrodes through which a variable pulsed shock (one 50 msec. duration pulse every second) could be delivered. The optimal shock for this phase was found to be 12-15 volts. The apparatus was programmed in such a way that one set of colored lights was always followed by shock whereas the other set of colored lights remained unpaired. (see Figure Ia)

The apparatus for instrumental avoidance acquisition was essentially a "fish shuttlebox". It consisted of a 10 gallon tank 52 cm. x 27 cm. x 31.5 cm., halved by a black plexiglas partition allowing a 4.5 cm. clearance underneath it. The level of water used was constantly 12.5 cm. A black plexiglas lid was fitted with 2 sets of 2 same-colored 71/2 watt light bulbs in such a way that when one color came on in one compartment of the shuttlebox, the other color came on simultaneously in the opposite compartment.

Each compartment of the shuttlebox was wired with its own set of aluminum mesh electrodes so that shock could be administered separately. Electrodes were placed along the front walls and the center partition of the compartments. This arrangement better reduced the shock leakage from the "danger" to the "safe" half of the shuttlebox as compared

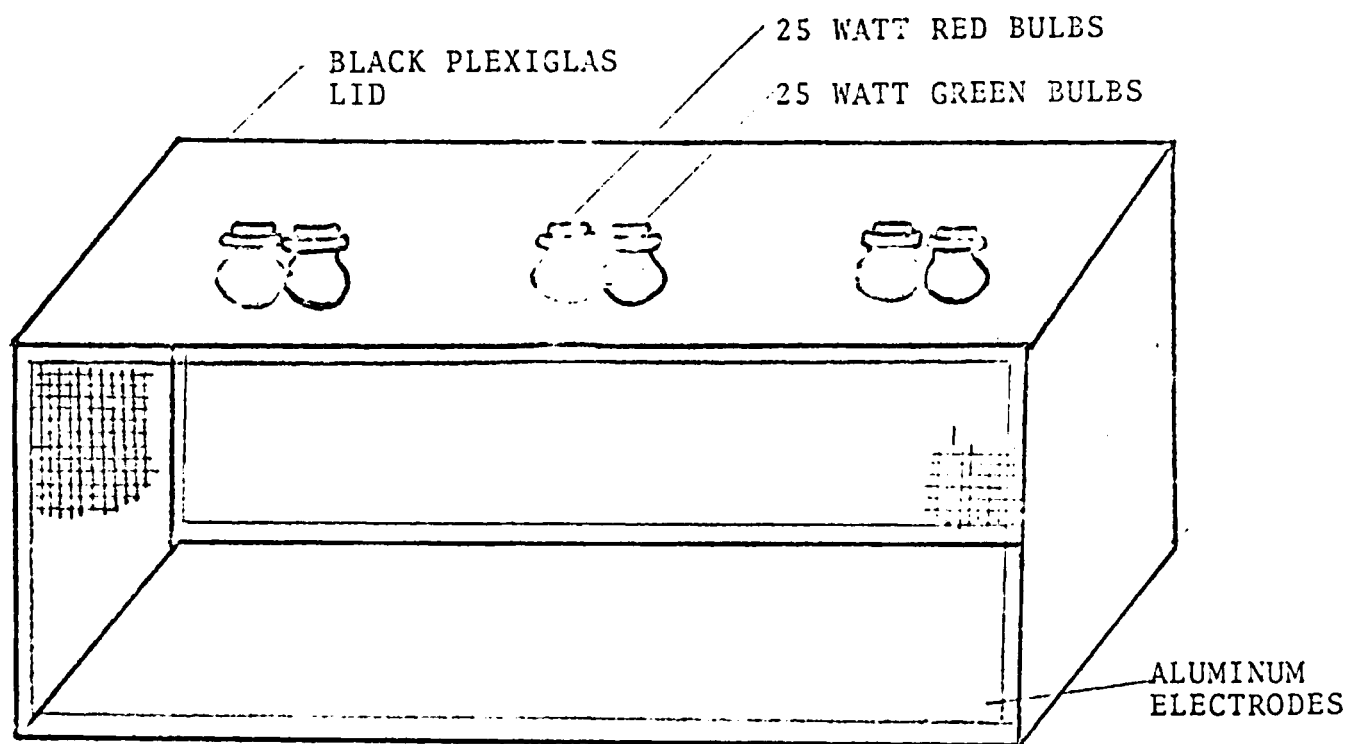


FIGURE 1a. PAVLOVIAN FEAR CONDITIONING APPARATUS

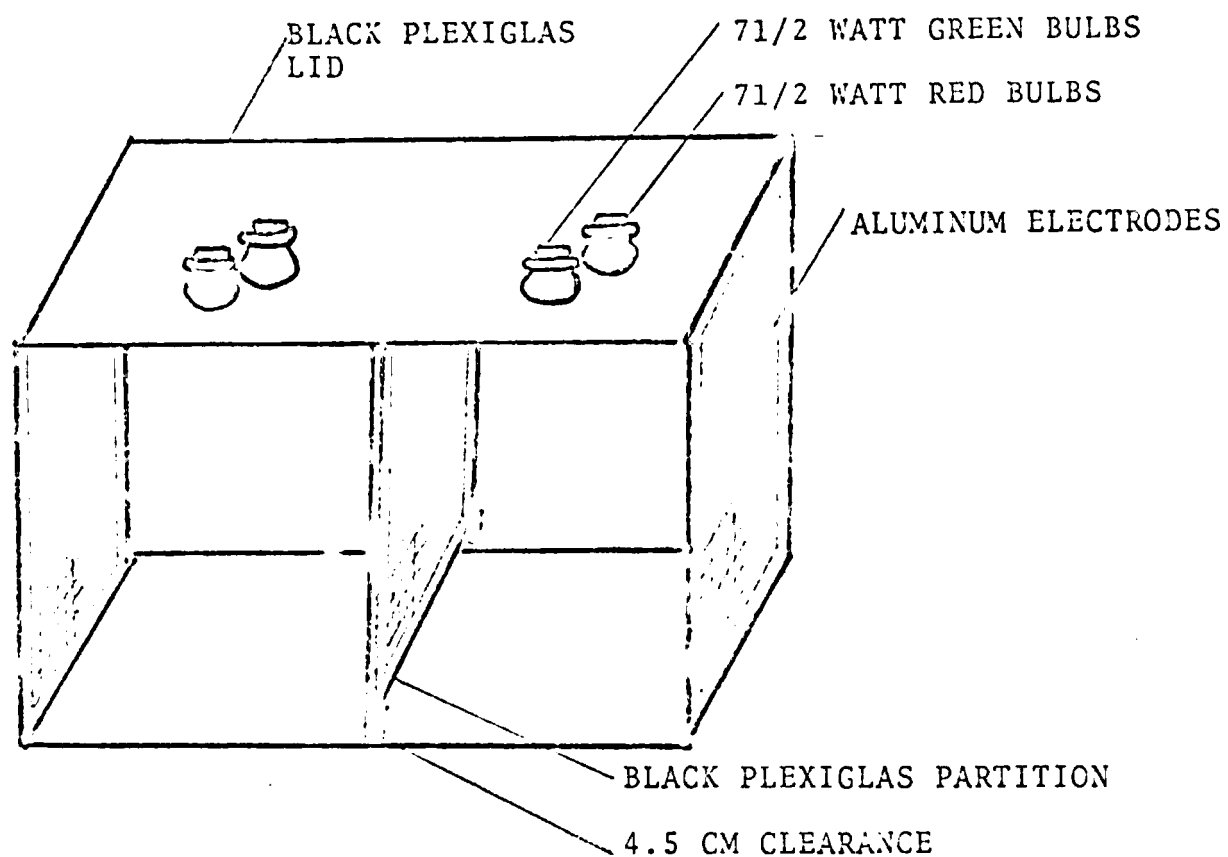


FIGURE 1b. AVOIDANCE CONDITIONING APPARATUS (SHUTTLEBOX)

to the conventional arrangement where electrodes were placed on the long walls of the apparatus.

The apparatus was programmed in such a way that the experimenter was able to control the side in which the danger signal CS^+ plus shock was to come on for any given trial. Throughout the duration of the CS^+ in the shocked compartment, the safe compartment was illuminated by the CS^- . The shock used in this phase was a 9 volt pulsed shock with the same pulsed characteristics. (see Figure Ib)

Procedure

The study consisted of two phases:

A. Prior Pavlovian fear conditioning

The 180 Ss were divided into three main groups Er, Eg, and C, with 60 Ss in each group. All Ss in Er received Pavlovian fear conditioning to CS^+ of red light with CS^- green light paired with no shock. Ss in Eg received Pavlovian fear conditioning to CS^+ of green light with CS^- red light paired with no shock. The control group had equal exposures to both red and green lights with no shock paired to either.

The technique of mass conditioning was employed. This involved running groups of 30 fish simultaneously instead of individually. Such a procedure is time saving and has been found by several investigators, Ungar (1971), and Eryant (1971), to be effective.

A delay conditioning paradigm was employed. The appropriate CS^+ was turned on in the box for 5 seconds after which a UCS of pulsed 12-15 volt shock was initiated. This together with the CS^+ continued on for an additional 10 seconds followed by a dark intertrial interval of 15 seconds. The CS^- then came on for 15 seconds unpaired with shock. This cycle repeated itself until a total of 30 exposures to the CS^+ was experienced by the Ss.

Each group received two days of such conditioning ie. a total of 60 exposures to the CS^+ . The control group received exposure to the entire series of lights without any shock for 2 days.

B. Instrumental avoidance acquisition

This phase constituted the test for transfer of training from classical fear conditioning to instrumental avoidance learning. It was initiated slightly more than 24 hours after the last fear conditioning trial.

Each of the main groups Er, Eg and C was split into six subgroups of 10 fish each (see Table I). Again mass conditioning procedures were employed with entire subgroups of 10 fish run simultaneously. Taking subgroup Er, R+G for example, the exact procedures were as follows:

For the first five avoidance conditioning trials, the CS^+ red light came on in the side with most fish. There was a simultaneous appearance of the CS^- green light in the

Table 1 Assignment of subjects to experimental treatments

Pavlovian Fear Conditioning Phase N=60 per group	Avoidance Conditioning Phase N=10 per group
<u>Er</u> CS ⁺ = red CS ⁻ = green	R → G ie. <u>Ss</u> made to avoid G → R red and approach R → Y green Y → R G → Y Y → G
	R → G G → R R → Y Y → R G → Y Y → G
	R → G G → R R → Y Y → R G → Y Y → G
<u>Eg</u> CS ⁺ = green CS ⁻ = red	
C exposure to red and green without shock	

opposite compartment which lasted the duration of the CS^+ . A pulsated shock of 9 volts was initiated in the red compartment 10 seconds after the onset of the CS^+ . Both the shock and the CS^+ continued on together for an additional 10 seconds followed by a dark intertrial interval of 40 seconds. The number of fish in the safe compartment at the onset of shock was considered the total number of avoidances for that trial. Fish that crossed from the shocked to the safe side after onset of shock were considered "escapes". After the fifth trial, the side in which the CS^+ was to appear was determined by the double alternation schedule LRLLRRL... . Ss were given 15 avoidance trials a day, and training was carried until at least one group reached the performance criterion of 80% avoidances for the day's session, or until performance began to level off. This took place on the ninth day of phase II, and training was accordingly terminated.

Statistical Treatment

With the technique of mass conditioning, no data are available for an individual subject's performance during a session. To analyze the overall differences in avoidance acquisition rates between groups, a t derivation for independent (uncorrelated) data with only N-1 degrees of freedom was used. All significant levels were two-tailed (Snedecor, 1946; Lewis, 1960). Such a test has been used by Bryant (1972) also on group data.

In the present case, N was the number of trials within a session (i.e., N=15). Data was collapsed over days for each trial within the sessions. The unit of analysis used was "average avoidance / fish / trial".

A basic assumption which has to be made with this application of the t is that the obtained scores for a given session must be considered a random sample of underlying population scores for that session. Such an assumption is at best unrealistic in this study since the "sampling" technique was more like systematic sampling than random sampling. Furthermore, with reinforced testing, processes such as learning would tend to produce positive correlations between trial scores for a given session between groups.

However, the use of Runs tests (Fellar, 1968) indicated that there were no systematic trends in either upward or downward directions among trial scores for any of the given sessions.

Results were also depicted by graphs with percentage of total possible avoidance per session for any given group graphed over the nine sessions (days).

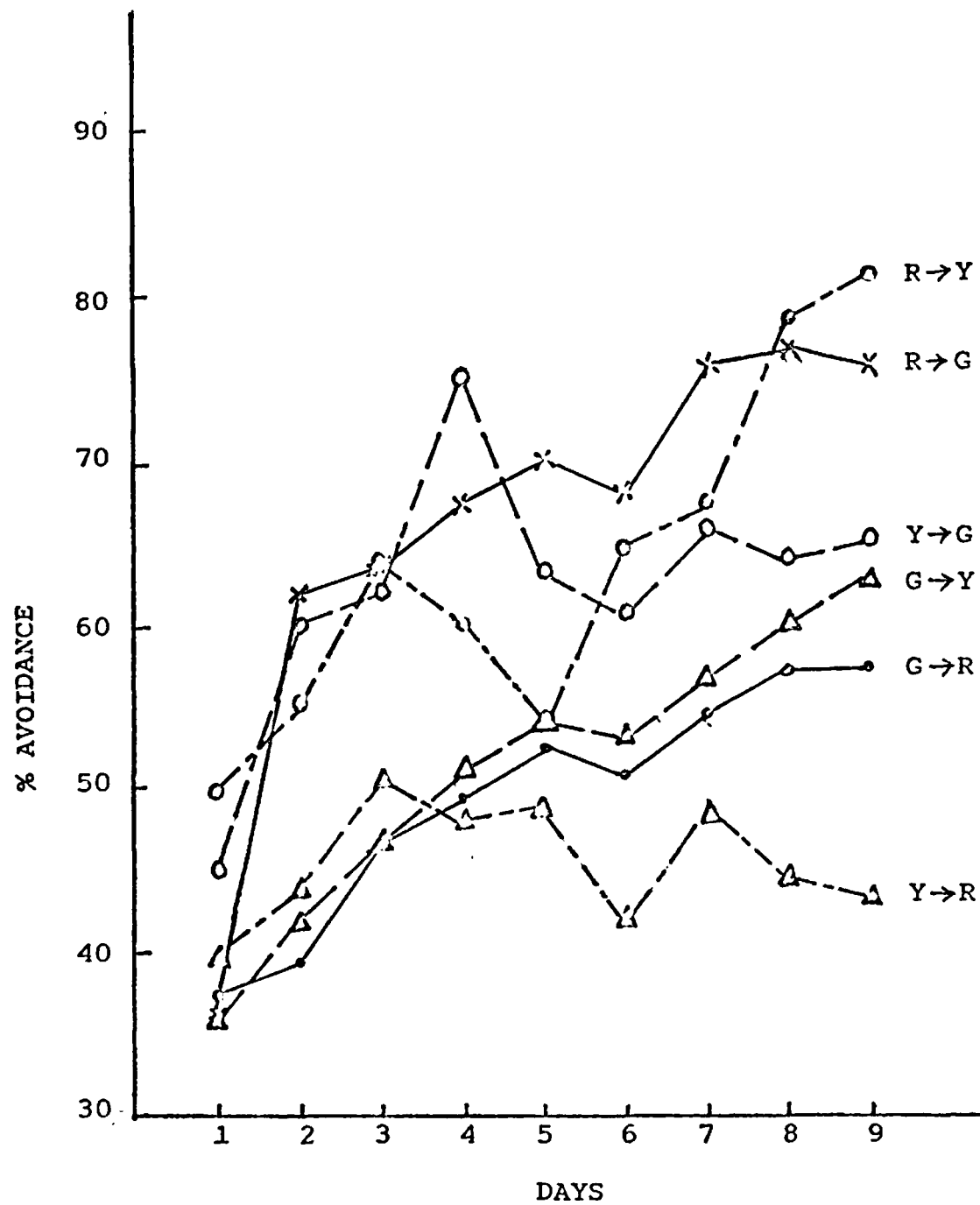
CHAPTER IV

RESULTS

Figure 2 illustrates the percentage of total possible avoidances as a function of training sessions for control groups on all avoidance tasks.

It is apparent from the figure that control groups learned these tasks at different rates reaching different end points with the R→Y group attaining 82% avoidances by the ninth day, followed by R→G, Y→G, G→Y, G→R, and Y→R in descending order of magnitudes. An examination of the average percentage of avoidances made by each control group over the nine sessions also revealed a similar hierarchy with the exception that R→G had a higher average percentage of avoidances than R→Y (68.1% as opposed to 63.9%). *t* tests of differences between the learning curves are presented in Table 2 in the Appendix. While there were no significant differences between R→Y, R→G, and Y→G, there was a significant difference at the $p = .05$ level between Y→G and G→Y ($t = 2.948$ two-tailed). This indicated that on the whole, R→Y, R→G, and Y→G were superior to the other tasks. *t* test between G→Y and G→R showed no significant difference whereas tests comparing G→Y to Y→R, and G→R to Y→R were significant at the

Figure 2. Percentage of total possible avoidances as a function of training sessions for control groups on all avoidance tasks



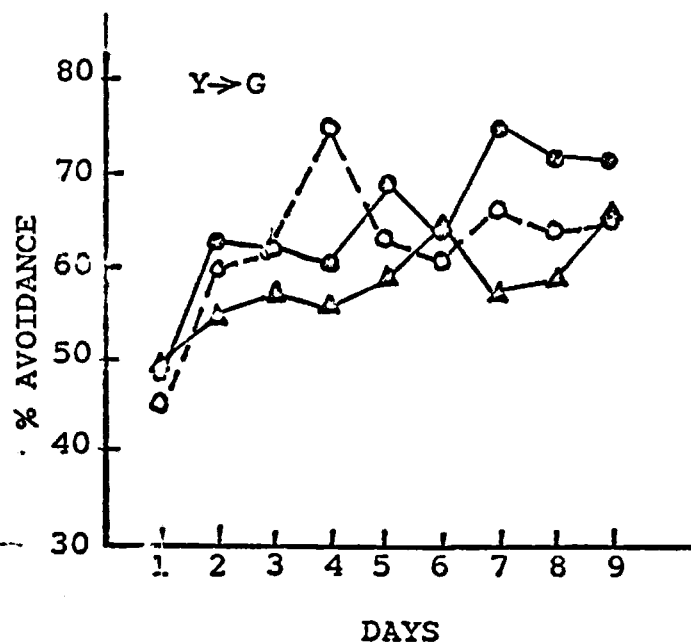
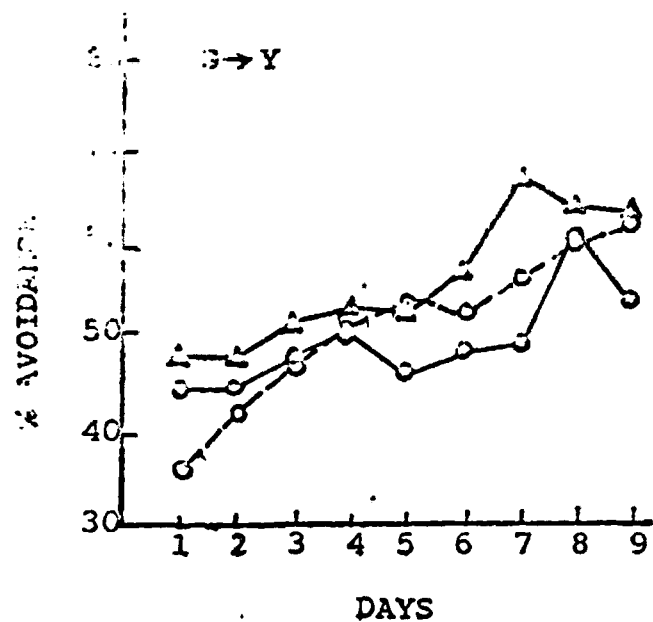
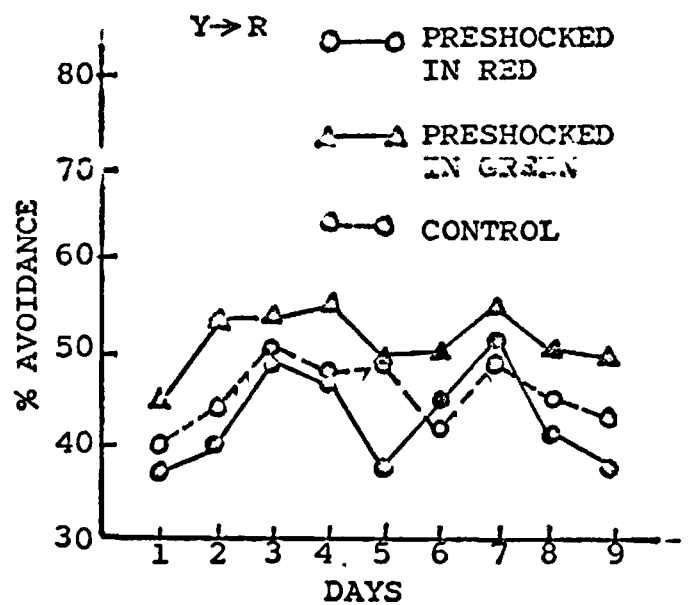
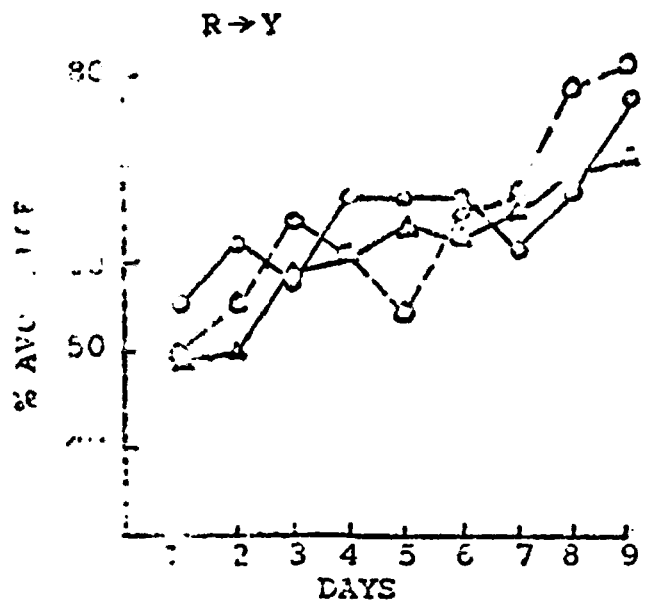
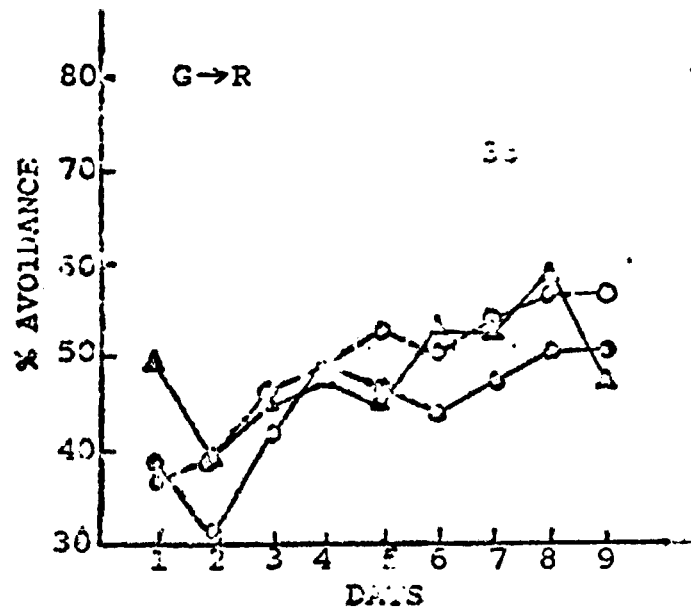
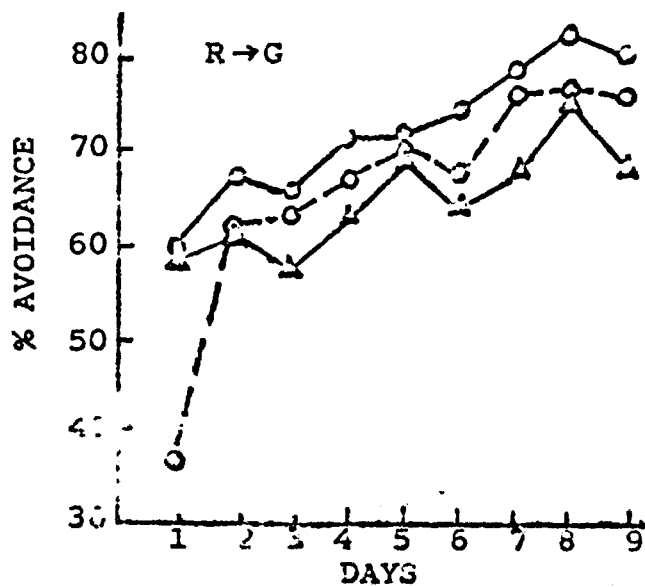
$p = .05$ level ($t = 3.4$, and $t = 2.67$ respectively). In effect then, there were three groups of avoidance tasks with differing ease of acquisition: $R \rightarrow Y$, $R \rightarrow G$, $Y \rightarrow G$; $G \rightarrow Y$, $G \rightarrow R$; and last of all $Y \rightarrow R$.

Figure 3 presents the acquisition curves of all groups for all avoidance tasks. These learning curves lend support to the thesis that prior Pavlovian fear conditioning does exert profound control over subsequent avoidance acquisition. With the possible exception of $R \rightarrow Y$ and $G \rightarrow R$ tasks, there were clear separations in learning curves between preshocked groups run in consistent avoidance tasks and preshocked groups run in inconsistent tasks. These differences were in the expected direction.

In all cases except the $R \rightarrow G$ task which represented the ideal results, the control groups fluctuated and overlapped both consistent and inconsistent experimental groups rendering it impossible to make any conclusions as to whether it was the consistent transfer which facilitated learning, the inconsistent transfer which interfered with learning, or both.

This overlap of control and experimental groups also made it obvious that although prior fear conditioning did affect subsequent avoidance acquisition in the expected direction, the effect was not of sufficient magnitude to alter the relative

Figure 3. . Percentage of total possible avoidances as a function of training sessions for all groups on all avoidance tasks.

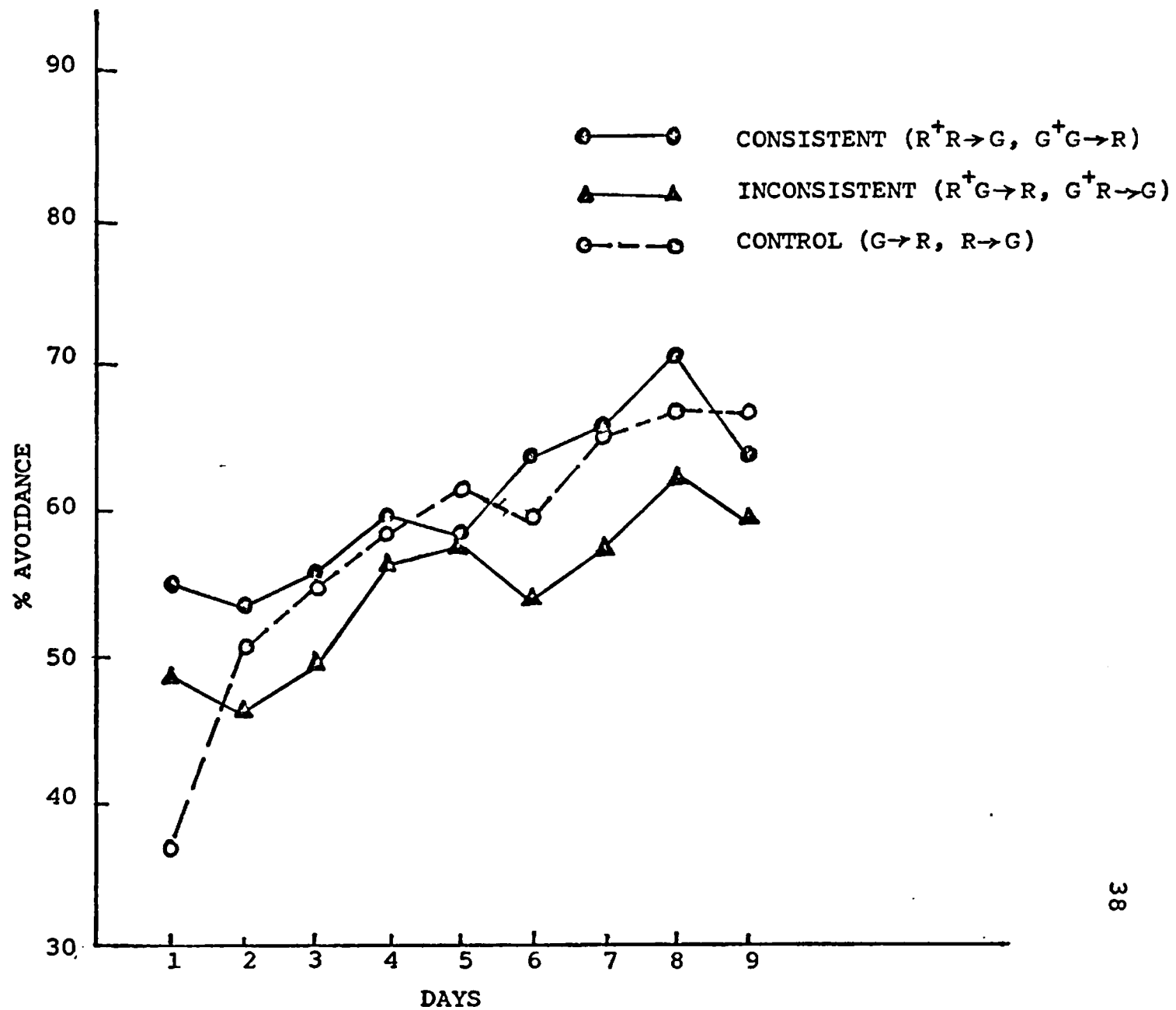


position of any learning curve in the hierarchy established by the control Ss discussed above. To put it differently, taking the average percentage of avoidances over all three groups within every comparison, the hierarchy of acquisition ease remained R+G, R+Y, Y+G, G+Y, G+R, and Y+R, with the respective average percentages of avoidances equal to 68%, 63%, 58.7%, 52.4%, 47.6% and 46.4%.

A final observation on Figure 3 is that in four out of six tasks, the control groups performed worse than both experimental groups on day 1.

Figure 4 depicts the results of the transfer of training portion of this study from discriminative Pavlovian fear conditioning to discriminative avoidance acquisition involving the same stimuli. Again, there were distinct and significant differences between the learning curves of consistent (R^+R^-G , G^+G^-R) and inconsistent (R^+G^-R , G^+R^-G) experimental groups ($t = 2.904$, significant at $p = .05$ level). Although these differences appear from the figure to have been due to the interference of learning in inconsistent groups, the t test between control and inconsistent groups did not prove to be significant ($t = 1.40$. See Table 3 in Appendix). The relatively low levels of performances in control groups on day 1 which is observable from Figure 3 can also be seen here. This may have resulted in an overall

Figure 4. Percentage of total possible avoidances as a function of training sessions for consistent discriminative transfer Ss ($G^+G \rightarrow R$, $R^+R \rightarrow G$), inconsistent discriminative transfer Ss ($G^+R \rightarrow G$, $R^+G \rightarrow R$), and control Ss ($G \rightarrow R$, $R \rightarrow G$).



reduction of the differences between control and inconsistent groups thus making the t test insignificant.

Figures 5, 6, and 7 deal with the issue of whether Ss learned specifically to avoid CS^+ and approach CS^- or whether they could avoid CS^+ to any other color and approach CS^- from any other color.

Figure 5a compares the learning curves of groups approaching a previously "safe" color from a neutral color with the learning curve of their respective controls. There were consistent differences in the expected direction between the two curves, but these differences did not approach significance ($t = .5$).

Figure 5b examines the same question utilizing an inconsistent task situation. Here, the comparison was between groups having to avoid a previously "safe" color into a neutral color and their respective controls. Again, differences in the expected direction were found, but these were of much smaller magnitudes ($t = 0.923$).

Figure 6a compares groups avoiding a previously shocked color into a neutral color with their respective controls. Differences between groups were again not significant ($t = 1.083$). Although there was a tendency for the differences to be in the right direction, this trend reversed itself by the eighth day of training.

Figure 5a. Percentage of total possible avoidances as a function of training sessions for Ss made to go from a neutral color to a previously "safe" color ($R^+Y \rightarrow G$, $G^+Y \rightarrow R$) and their respective controls ($Y \rightarrow G$, $Y \rightarrow R$)

Figure 5b. Percentage of total possible avoidances as a function of training sessions for Ss made to go from a previously "safe" color to a neutral color ($R^+G \rightarrow Y$, $G^+R \rightarrow Y$) and their respective controls ($G \rightarrow Y$, $R \rightarrow Y$)

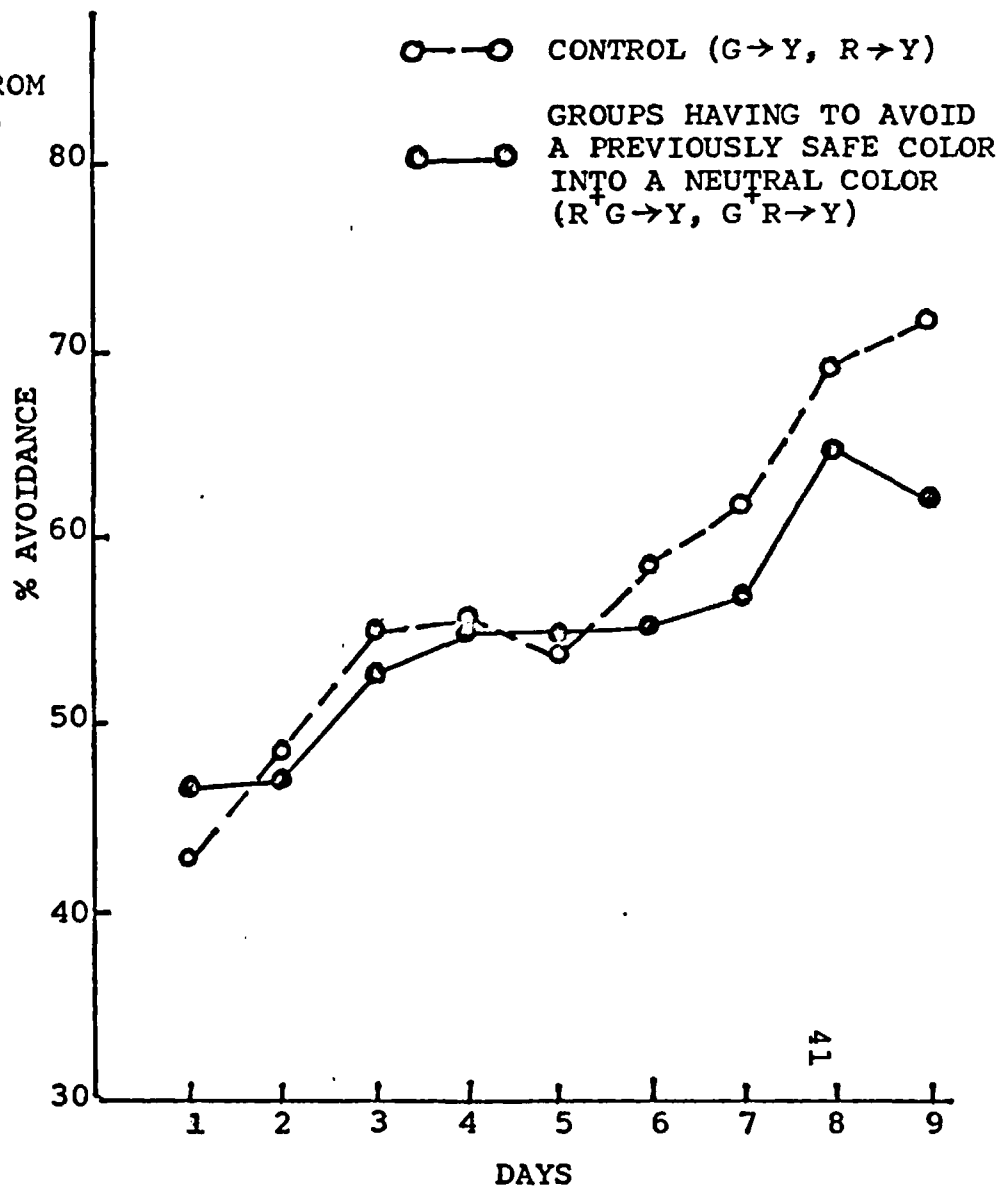
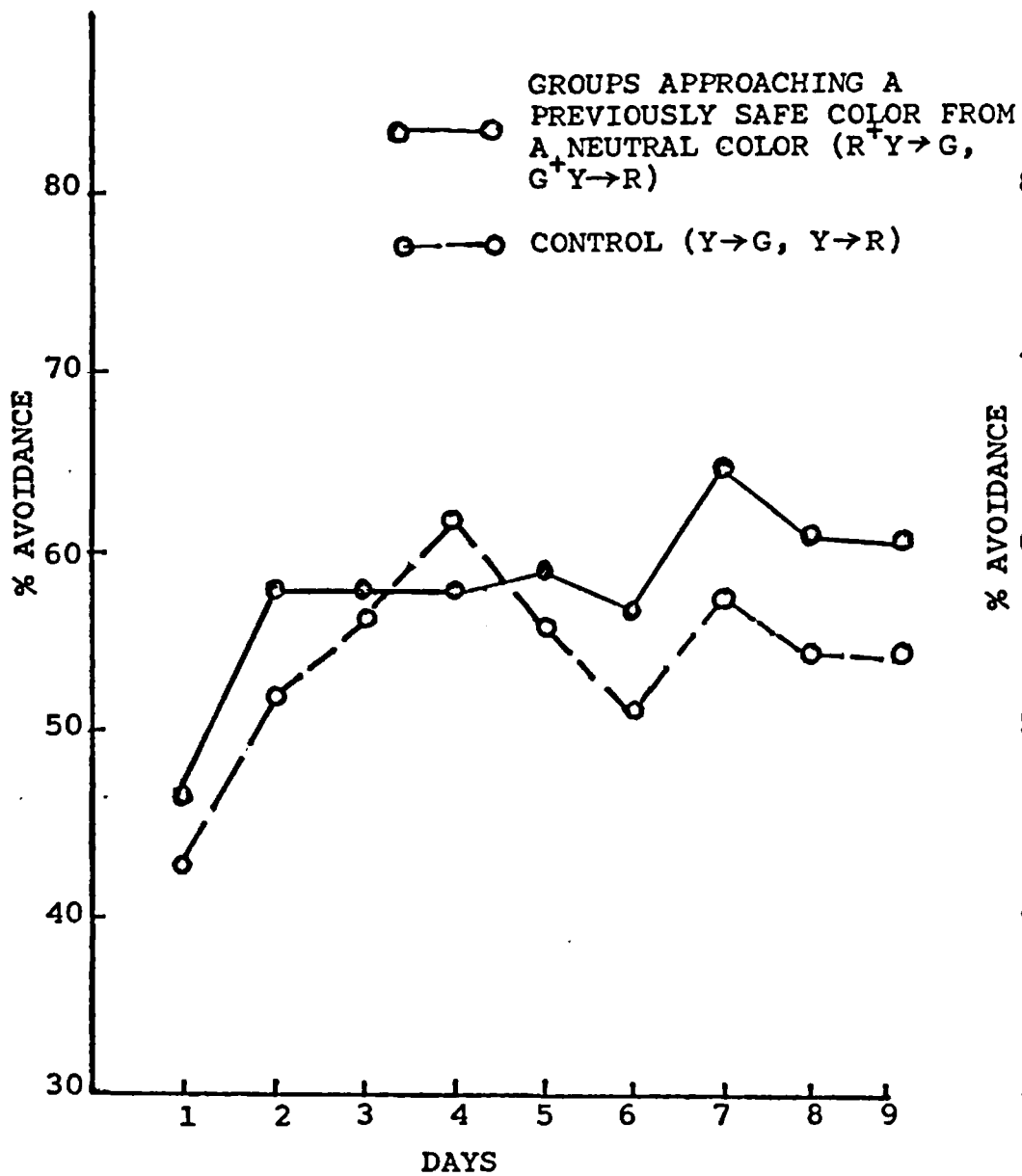


Figure 6a. Percentage of total possible avoidances as a function of training sessions for Ss made to go from a previously shocked color into a neutral color ($R^+R \rightarrow Y$, $G^+G \rightarrow Y$) and their respective controls ($R \rightarrow Y$, $G \rightarrow Y$)

Figure 6b. Percentage of total possible avoidances as a function of training sessions for Ss made to go from a neutral color into a previously shocked color ($G^+Y \rightarrow G$, $R^+Y \rightarrow R$) and their respective controls ($Y \rightarrow G$, $Y \rightarrow R$)

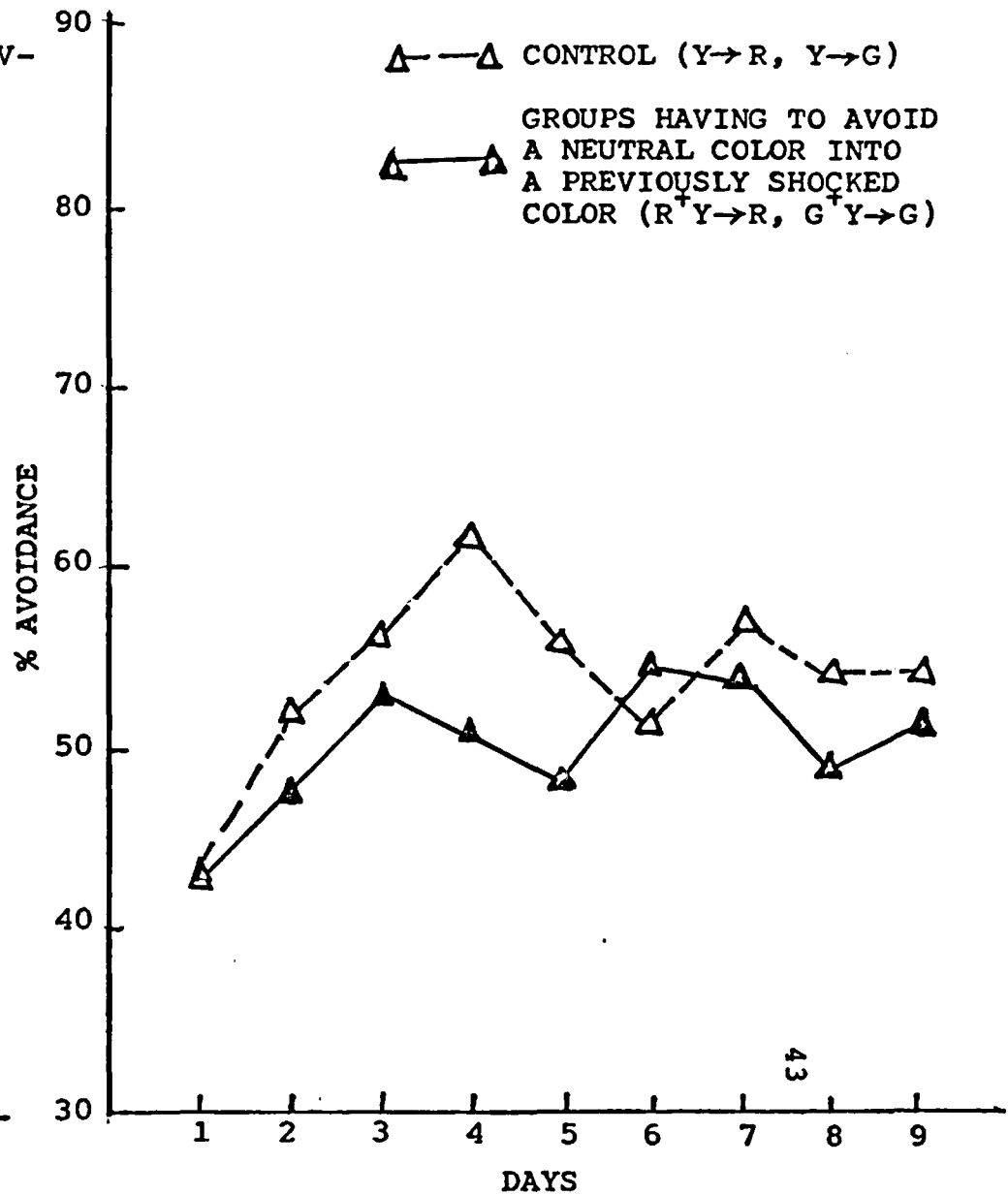
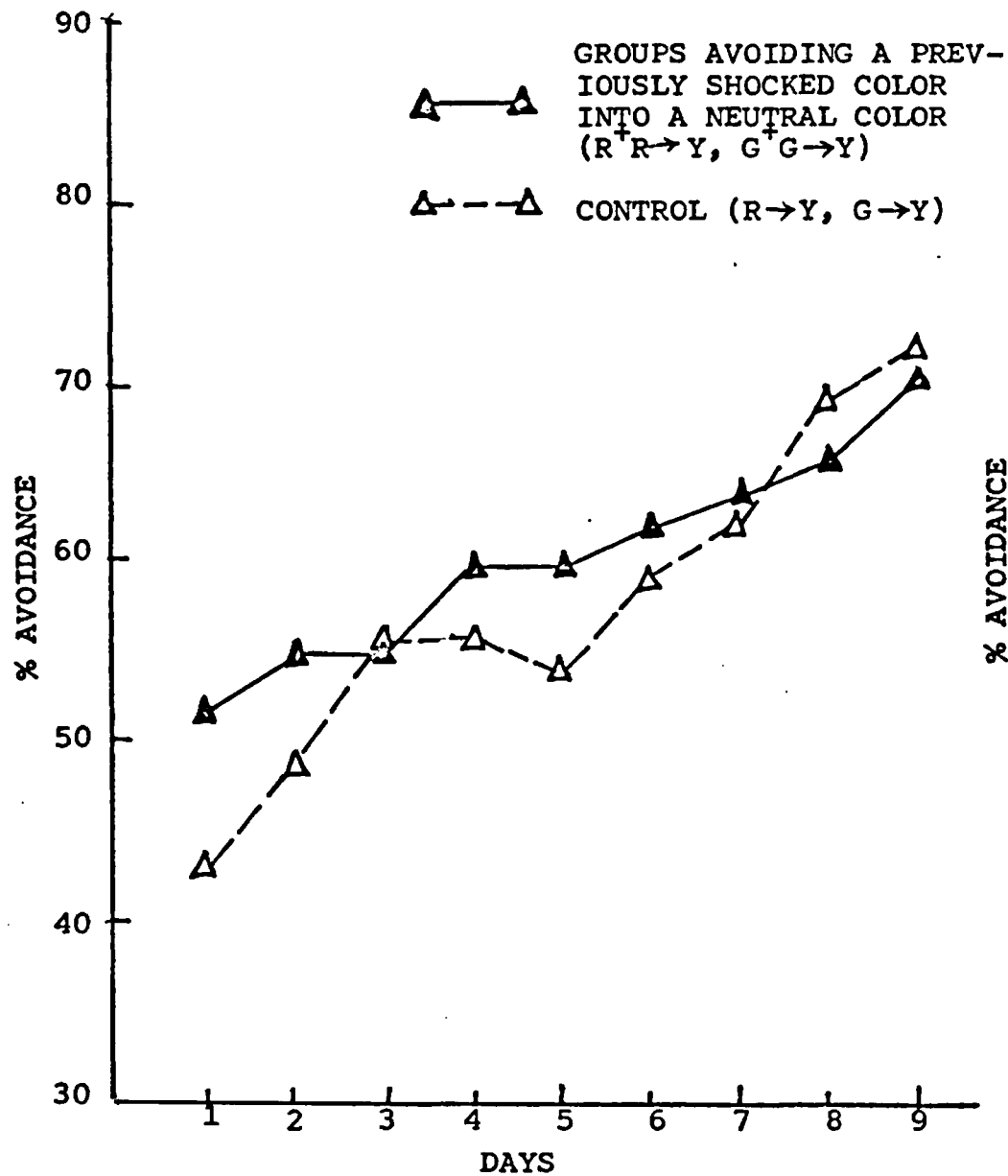
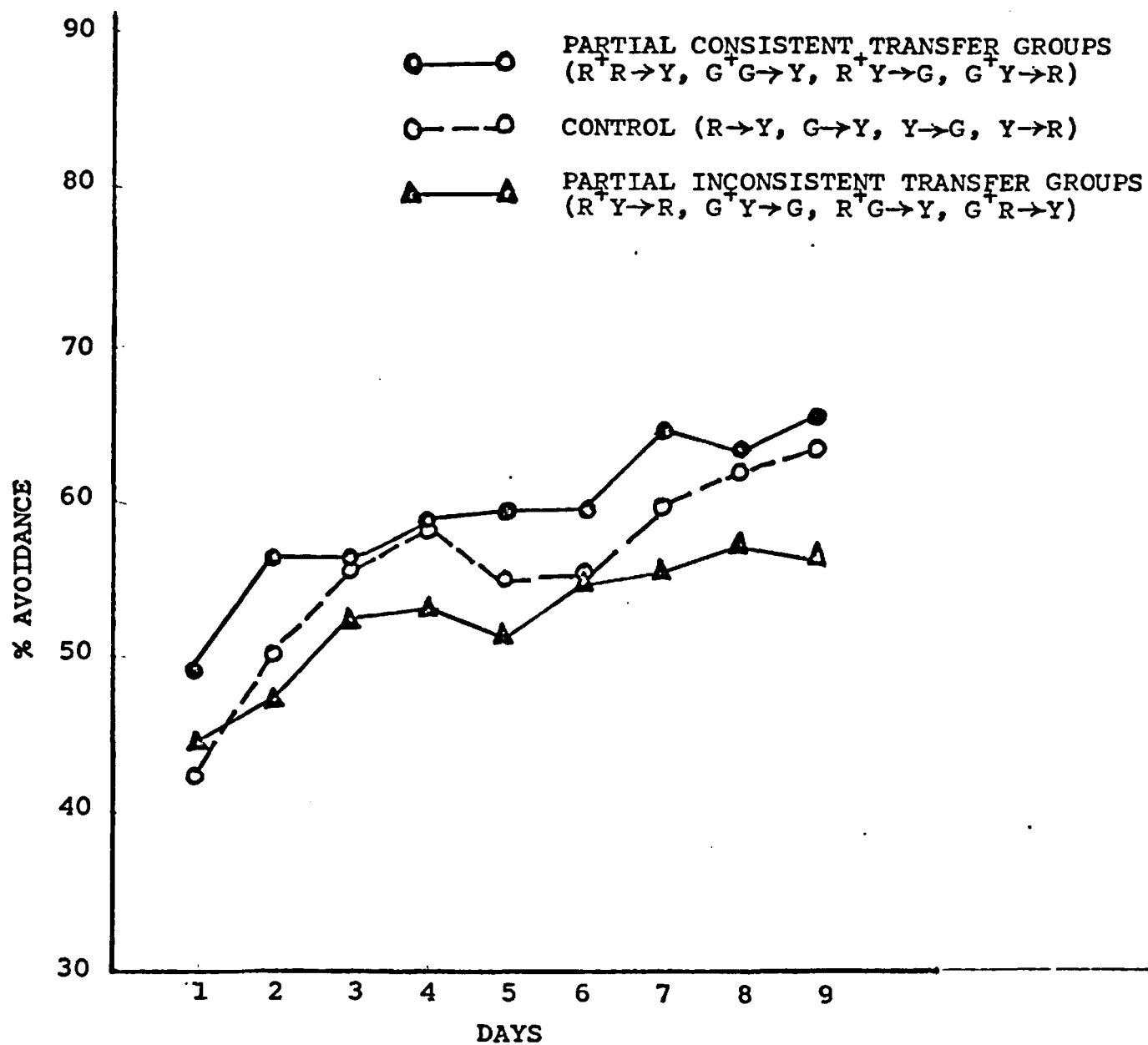


Figure 6b examines the same question as 6a utilizing an inconsistent task situation. The comparison was between groups having to avoid a neutral color into a previously shocked color and their respective controls. In this case, the magnitudes of differences between groups were found to be quite substantial although still not sufficient to produce significance ($t = 1.5$). A summary of the t tests for Figures 5 and 6 may be seen in Table 4 in the Appendix.

It may be concluded at this point that Ss which had received prior discriminative fear conditioning showed strong tendencies to approach CS^- from a neutral color and avoid CS^+ to another color. However, these tendencies were not statistically significant.

The cumulative results of Figures 5 and 6 are presented in Figure 7. This figure illustrates in effect a partial discriminative transfer situation in which only one stimulus from the classical conditioning phase is carried through to the instrumental avoidance phase. The partial consistent transfer Ss performed reliably and significantly better than the partial inconsistent transfer Ss ($t = 2.59$, significant at $p = .05$ level; See Table 5). Control performance was intermediate as expected, but was not significantly different from either experimental group.

Figure 7. Percentage of total possible avoidances as a function of training sessions for consistent partial discriminative transfer Ss ($R^+R \rightarrow Y$, $G^+G \rightarrow Y$, $R^+Y \rightarrow G$, $G^+\bar{Y} \rightarrow R$), inconsistent partial discriminative transfer Ss ($R^+Y \rightarrow R$, $G^+Y \rightarrow G$, $R^+G \rightarrow Y$, $G^+R \rightarrow \bar{Y}$) and control Ss ($Y \rightarrow R$, $Y \rightarrow G$, $G \rightarrow Y$, $R \rightarrow Y$)



Again, a relatively low percentage of avoidances was evident in the control group on day 1.

CHAPTER V

DISCUSSION

The discussion roughly parallels the sequence of results and figures presented earlier.

1) Comparisons between control avoidance acquisition curves revealed a strong pre-experimental color preference hierarchy in fish with green being the most preferred color, then yellow, and least of all red. This is evident from the finding that the hierarchy of acquisition ease in the various tasks was R→G, R→Y, Y→G, G→Y, G→R, and Y→R for control Ss. Results also indicated that yellow was closer to green than to red on a "subjective scale" as the G→Y and Y→G tasks were adjacent to each other in acquisition ease. This preference hierarchy supports Galvan's findings (1971) rather than Zippel and Domagk's (1969).

It will be remembered from Chapter II that Galvan established a preference hierarchy of green>blue>red in his goldfish population also from Ozark Fisheries, Missouri, whereas Zippel and Domagk using Italian goldfish found a characteristic strong aversion to green. This difference could therefore be a function of the source of the fish population.

An interesting observation which has yet to be confirmed is that although American goldfish seem to fear red as a rule, such a marked aversion to red as revealed by the present study does not appear so evident when fish are merely screened for preference. Hoffman (1972) reports that fish spend consistently a little over 55% of the time in green as opposed to red when they are screened for preference without shock. It is highly speculative, but it could be that strong aversion to red is somehow associated with the presence of shock.

2) It could be gathered from Figure 3 that while prior Pavlovian fear conditioning affected subsequent avoidance acquisition in the expected direction, the general preference hierarchy remained unchanged nonetheless. Such results do not agree with the findings of Laird, Richards and Braud (1972). Using a similar discriminative Pavlovian fear conditioning technique with red and green colors, they were able to demonstrate a reversal in pre-experimental color preference.

This difference in findings could conceivably be attributed to two factors, the choice of the "index of preference" and the involvement of shock. In Laird et al's study, "preference" was the amount of time spent by the fish in a certain color whereas in the present study, "preference" was avoidance acquisition ease. The latter involved shock whereas the former did not.

3) Also evident from Figure 3 is the observation that

prior fear conditioning affected subsequent avoidance acquisition over all nine days of training. Such a permanence of the pretraining effect was not found by Walker (1942). Again, this could be accounted for by the fact that Walker used non-reinforced testing in his study, and the avoidance response probably underwent extinction. In the present study, however, reinforced testing was used thus maintaining the pretraining effect.

4) A phenomenon which has been observed with relative consistency in this experiment is that even the inconsistent transfer Ss tended to perform better than control Ss on day 1 of avoidance training.

A plausible explanation for this phenomenon utilizes the findings of Kurtz and Walter (1962), and Kurtz and Pearl (1960). These researchers claim that experiences of intense fear predispose animals to react with increased fear upon subsequent encounters with aversive stimuli. Thus, the relatively high percentages of avoidances in inconsistent transfer Ss on day 1 could have resulted from increases in their general activation levels due to prior experiences with shock.

This phenomenon almost invariably disappears by day 2. It could be that the phenomenon is simply overcome by the learning processes developing in control Ss after day 1.

5) Before discussing the two major outcomes of the present study, a close examination of control behavior is essential.

This is because the interpretations of many vital results depend upon comparisons between control and experimental performances. For instance, in order to conclude whether an experimental animal has learned to avoid CS⁺ into a neutral color, one must compare the performance of an appropriately preshocked E group to the performance of a non-preshocked control group.

Throughout the training sessions for most comparisons (see Figure 3), control performances fluctuated erratically, overlapping both consistent and inconsistent transfer groups. This precluded the possibility of drawing any conclusions as to whether the differences between the consistent and inconsistent transfer conditions were due to facilitation of learning in the former condition, interference of learning in the latter condition, or both.

In point of fact, the question of whether the "correct" control group was used remains debatable. Mellgren and Ost (1969) working with an appetitive transfer of training task argue that the optimal control group is one in which reinforcement is presented without the stimuli. Such a control would not have been feasible in the present study as negative reinforcement (shock) was used and "learned helplessness" may have resulted.

Lubow and Moore (1959) claim that non-reinforced presentations of the CSs during classical conditioning such as the

procedures adopted in the present study, would lead to sluggish subsequent instrumental discrimination. This did not appear to have been the case from the present results since control performances overlapped consistent transfer group performances as well as inconsistent transfer group performances. Furthermore, Rescorla and Lolordo (1965) find that in order for a stimulus to suppress fear and thus performance, it has to be explicitly paired with no-shock on a background of shock. Such suppression would thus only occur in control groups where both shock and stimuli are present but explicitly unpaired.

6) Transfer of training from discriminative Pavlovian fear conditioning to discriminative avoidance conditioning involving the same stimuli has been successfully demonstrated (see Figure 4). Consistent discriminative transfer Ss performed significantly better than inconsistent discriminative transfer Ss over all nine days of avoidance training. It appears from the figure that these differences were due to interference of learning in the inconsistent transfer group as the control curve tended to overlap the consistent transfer curve. However, a t test between control and inconsistent groups did not prove significant. This lack of significance could have been caused by the high percentage of avoidances in the inconsistent transfer group on day 1. This would have reduced the overall differences in performance between

control and inconsistent groups. Finally, such a comparison may be totally meaningless since there is doubt as to whether the appropriate control group was used.

7) There are indications that fish are not as "concrete" or "stimulus bound" as others have believed (Bitterman, 1968). Experimental Ss did not merely learn to avoid CS^+ and approach CS^- as a unit, but were able to avoid CS^+ into another color and approach CS^- from another color. This meant that they were able to generalize what they had learned in one situation to another situation. Furthermore, the fact that these Ss could approach CS^- from another color indicates that the CS^- had become affectively positive for them.

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APPENDIX
TABLES OF t VALUES FOR ALL FIGURES

Table 2 t values for Figure 2

	R → G	R → Y	Y → G	G → Y	G → R	Y → R
R → G		1	1.48	5.63*	6.31*	9.16*
R → Y			.78	4.92*	5.65*	8.73*
Y → G				2.94*	3.5 *	5.76*
G → Y					0.65	3.4 *
G → R						2.67*
Y → R						

* = significant at the $p = 0.05$ level
 $t = 2.145$ $df = 14$ two-tailed

Table 3 t values for Figure 4

GROUPS	t values
Consistent ($G^+G \rightarrow R$, $R^+R \rightarrow G$) and Inconsistent ($G^+R \rightarrow G$, $R^+G \rightarrow R$)	2.904*
Consistent and Control ($G \rightarrow R$, $R \rightarrow G$)	1.47
Inconsistent and Control	1.40

* = significant at the $p = 0.05$ level
 $t = 2.145$ $df = 14$ two-tailed

Table 4 t values for Figures 5 and 6

GROUPS	t values
neutral to "safe" ($R^+Y \rightarrow G$, $G^+Y \rightarrow R$) and control ($Y \rightarrow G$, $Y \rightarrow R$)	.5
"safe" to neutral ($R^+G \rightarrow Y$, $G^+R \rightarrow Y$) and control ($G \rightarrow Y$, $R \rightarrow Y$)	.923
"shocked" to neutral ($R^+R \rightarrow Y$, $G^+G \rightarrow Y$) and control ($R \rightarrow Y$, $G \rightarrow Y$)	1.083
neutral to "shocked" ($R^+Y \rightarrow R$, $G^+Y \rightarrow G$) and control ($Y \rightarrow R$, $Y \rightarrow G$)	1.5

all t values not significant

Table 5 t values for Figure 7

GROUPS	t values
Partial consistent ($R^+R \rightarrow Y$, $G^+G \rightarrow Y$, $R^+Y \rightarrow G$, $G^+Y \rightarrow R$) and partial inconsistent ($R^+Y \rightarrow R$, $G^+Y \rightarrow G$, $R^+G \rightarrow Y$, $G^+R \rightarrow Y$)	2.59*
Partial consistent and control ($R \rightarrow Y$, $Y \rightarrow R$, $G \rightarrow Y$, $Y \rightarrow G$)	.76
Partial inconsistent and control	1.46

* = significant at the $p = 0.05$ level
 $t = 2.145$ $df = 14$ two-tailed