TO MY DAUGHTER, CARYN.

THE EFFECTS OF A PRE-AVERSIVE STIMULUS UPON THE OPERANT BEHAVIOR OF HUMAN SUBJECTS

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

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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by
James Marvin Elliott
January 1966

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James M. Elliott

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AN ABSTRACT

The purpose of this study was to evaluate the effects of a pre-aversive stimulus followed by unavoidable shock upon human behavior. Twenty paid volunteer male college students were used as subjects. Subjects were randomly assigned to two equal groups. Ten subjects were assigned to the Avoidance Group and 10 subjects were assigned to the Positive Reinforcement Group. Each subject performed a two hour vigilance task.

The Avoidance Group monitored 3 volt meters by pressing 3 corresponding push-button switches. Pointer deflections, or signals were presented on a two minute variable interval schedule. The signals remained on the meters for 5 seconds, and if they were not detected within this time, a 10 ma AC electric shock was delivered to the left leg of the subject for a duration of 150 msec.

The Positive Reinforcement Group performed the same task but without the shock contingency. Instead they received a dime for every signal detected. An illuminated counter on the subjects' console kept him informed as to the number of signals detected. Signals were presented on a VI-2' schedule, and remained for 30 seconds or until detected by the subject.

At the beginning of the 30th minute of the session a pre-aversive stimulus (clicker) was presented. The pre-aversive stimulus remained on for one-minute, and at the end

of the minute it was terminated and an unavoidable electric shock was delivered to the subject. This procedure was repeated nine times making a total of 10 pre-aversive stimulus-shock trials.

Four of the subjects in the Avoidance Group showed a significant increase in observing response rate during the pre-aversive stimulus and one subject showed a significant suppression in response rate. Five subjects did not exhibit reliable behavioral changes during the pre-aversive stimulus..

Likewise, 4 subjects in the Positive Reinforcement Group showed a significant increase in observing response rate during the pre-aversive stimulus and one subject showed a significant suppression in response rate. Five subjects did not exhibit reliable behavioral changes during the pre-aversive stimulus.

In view of these findings it was concluded that the response facilitation in both groups was most likely the result of an enextinguished avoidance and escape history of the subjects, and the pre-aversive stimulus acted as a discriminative stimulus for emitting avoidance-like responses which had been effective in avoiding or escaping noxious stimuli in the past.

The basal skin resistance data were generally low for both groups and due to its relatively long recovery time it did not provide any useful information relative to the effects of the pre-aversive stimulus and operant behavior.

The heart rate data revealed that 7 subjects in the Avoidance Group and 9 in the Positive Reinforcement Group showed significant heart rate increases during the pre-aversive stimulus. Comparing the heart rates between the two groups revealed no significant differences between them before the pre-aversive stimulus trials although the subjects in the Avoidance Group had slightly higher rates. When the percentage increase in heart rate during the pre-aversive stimulus trials were compared, the Positive Reinforcement Group showed a significantly greater increase than the Avoidance Group on the first trial and also on the percentage increase on all 10 pre-aversive stimulus trials. It was concluded from these analyses that the Avoidance Group was under greater "stress" than the Positive Reinforcement Group due to the fact that the pre-aversive stimulus did not induce equal heart rate changes in the two groups. Thus it is hypothesized that increments in stress level results in non-linear increments in heart rate. That is, equal increments in stress level will result in a negatively acclerated heart rate lability curve.

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

CHAPTER I

THE PROBLEM

Psychology, by taking behavior into the experimental laboratory where it can be objectively scrutinized and reported, has made notable advances in the past few decades. Laboratory studies of animal and human behavior have done much to dispel erroneous concepts and myths which have surrounded behavior in the past. The principles of behavior derived from laboratory studies are not merely of academic interest, but, if used judiciously and adroitly, these principles can be effective in the practical shaping, maintaining, and control of behavior across a wide range of organisms, including the human. The effectiveness of these principles, of course, depends partially upon the extent of our knowledge concerning the behavioral phenomena observed in the laboratory and upon the extent to which we are justified in generalizing across species.

There are certain obvious dangers in generalizing too broadly without sufficient data. Indeed, Thorndike (1913) made the generalization that:

> When a modifiable connection between a situation and a response is made and is accompanied or followed by a satisfying state of affairs, that connection's strength is increased; When made and accompanied or followed by an annoying state of affairs, its strength is decreased (p. 4).

Little change has been made in his original assertion concerning reward; but, with respect to punishment, Thorndike

(1932) was obliged to reexamine his original position on the basis of human studies of verbal learning.

Positive reinforcement of human behavior has been studied in a laboratory situation and the data, to a large extent, are quite analogous to those obtained from infrahuman subjects. Punishment, on the other hand, has not been explored as extensively using humans as subjects. Consequently, most of the principles and generalizations about punishment are based on experimental studies of lower organisms. Therefore, it would seem to be desirable that this area be explored, where practical, using higher organisms.

It is true that several studies have replicated the animal data with humans (Ader & Tatum, 1963; Weiner, 1963; Weiner, 1964; Frazier, 1964; Elliott, 1964) using various operant techniques. Nevertheless, there are some behavioral phenomena observed in animals which have not been attempted, or, at least, not reported with human subjects. Notable among these is the conditioned suppression phenomenon as originally reported by Estes and Skinner (1941). In this procedure a rat working a a positive reinforcement schedule is presented a neutral, but novel, easily identifiable stimulus for a predetermined period of time; when the stimulus is terminated, a shock is delivered to the organism. After several presentations of the pre-aversive stimulus terminated by unavoidable shock, the animal's response rate drops to zero, or nearly zero, for the duration of the pre-aversive stimulus, and then resumes at the original rate after the shock. The noxious stimulus is not contingent upon a response; nevertheless, there is a strong effect on the ongoing behavior of the rat. There have been several additional studies which have extended this finding by showing that a pre-aversive stimulus suppresses the response rates of several other species on various schedules of positive reinforcement (Azrin, 1956; Brady, 1955; Brady & Hunt, 1955; Sidman, 1956; and Valenstein, 1959).

However, it is not always the case that behavior is suppressed in the presence of a pre-aversive stimulus. If the animal has a history of avoidance training, the pre-aversive stimulus may actually facilitate responding (Sidman, Herrnstein, & Conrad, 1957; Waller & Waller, 1963).

The major purpose of the study is to offer empirical evidence of phylogenetic continuity of the behavioral effects of aversive stimulation. If this is indeed the case, then we can be more confident that behavioral principles based primarily upon infra-human studies can be successfully extrapolated to the human.

It remains to be demonstrated, however, whether the response suppression and response facilitation phenomena can be produced in humans during a pre-aversive stimulus. It is almost inconceivable that a "warning" signal signifying an impending aversive stimulus would have no effect upon the behavior of a human subject. This effect should be manifested in the overt behavior of the subject which can be objectively described and reported.

This study was designed to confront human subjects with a "pre-aversive" stimulus consistently followed by unavoidable shock while working on two different schedules of reinforcement. One schedule using positive reinforcement and the second being a shock-avoidance schedule. On the basis of infra-human studies, it would be predicted that humans will show some degree of response suppression in the presence of the pre-aversive stimulus while working on the positive reinforcement schedule, whereas there will be some degree of response facilitation during the pre-aversive stimulus for subjects performing on a schedule involving an avoidance component.

CHAPTER II

REVIEW OF LITERATURE

Conditioned Suppression

The phenomenon of conditioned suppression has generated considerable interest since being introduced into the literature by Estes and Skinner (1941). The technique which characteristically produces conditioned suppression has been used in many studies with animal subjects, and has provided the experimental psychologist a tool with which he can further broaden our understanding of behavior.

In their original study, Estes and Skinner (1941) were interested in investigating some quantitative properties of the concept of anxiety, which they report as having at least two defining characteristics. Anxiety is:

> (1) an emotional state, somewhat resembling fear, and (2) the disturbing stimulus which is principally responsible does not precede or accompany the state but is 'anticipated' in the future (p. 390).

In order to condition a state of anxiety, rats were trained to press a bar to receive food periodically. When the bar-press response occurred at a stable rate, a tone was sounded for 3 minutes. At the end of the 3 minutes an electric shock was delivered through grids in the floor of the experimental box. Initially, there was no observable effect of the tone upon the response rate of the rats, but with repeated exposure to the tone-shock pairing the rats ceased responding at the onset of the tone. Response rate was near zero for the duration of the tone and after the shock was delivered, they began responding at approximately their pre-tone rate. Estes and Skinner point out that:

> The modification in behavior correlated with the anticipation of a disturbing stimulus cannot be attributed to a negative reinforcement of the response to the lever, since the shock was always given independently of the rat's behavior with respect to the lever (p. 393).

In their concluding remarks, Estes and Skinner (1941) wrote:

> Anxiety is here defined as an emotional state arising in response to some current stimulus which in the past has been followed by a disturbing stimulus. The magnitude of the state is measured by its effect upon the strength of hunger-motivated behavior, in this case the rate with which rats pressed a lever under periodic reinforcement with food. Repeated presentations of a tone terminated by an electric shock produced a state of anxiety in reponse to the tone, the primary index being a reduction in strength of the hunger-motivated behavior during the period of the tone. When the shock was thus preceded by a period of anxiety, it produced a much more extensive disturbance in behavior than an 'unanticipated' shock (p. 400).

In a similar vein to account for conditioned suppression, somewhat later Skinner (1953) said:

> A stimulus which characteristically precedes a strong negative reinforcer has a far-reaching effect. It evokes behavior which has been conditioned by the reduction of similar threats and also elicits strong emotional responses.... Operant behavior will be also markedly changed. ...(changes in operant behavior) can occur, however, only when a stimulus characteristically <u>precedes</u> an aversive stimulus by an interval

> of time sufficiently great to permit behavioral changes to be observed. The condition which results is usually called anxiety (p. 178).

Conditioned suppression has been shown to be a highly reproducible phenomenon. Brady (1956) used it as a technique to assess the effects of tranquilizing drugs on the emotional behavior of rats. When suppression had developed to the stimulus preceding shock, a tranquilizer (reserpine) was administered to the rat. The tranquilizer had a general effect of lowering the overall response rate and of eliminating the conditioned suppression effect. The response rate during the pre-aversive stimulus was indistinguishable from other portions of the cummulative record. On the other hand, doses of a stimulant (amphetamine) produced an overall response rate increase, but suppression was complete during the pre-aversive stimulus.

Conditioned suppression of a response maintained by food-reinforcement has been reported for a number of diverse species of animals. Geller (1964) investigated conditioned suppression in goldfish as a function of the shock-reinforcement schedule. He found that acquisition of conditioned suppression was faster and extinction of the suppression was longer in fish that were shocked on 100% of the pre-aversive stimulus shock trials than in fish who received a shock on 50% of such trials.

Valenstein (1959) has used the Estes-Skinner procedure with guinea pigs in drug studies. Lyon (1963) used pigeons to study frequency of reinforcement as a parameter of conditioned suppression.

Conditioned Facilitation

When behavior is being maintained by food-reinforcement, the introduction of electric shock preceded by an indentifiable stimulus results in suppression of response rate in the presence of the pre-aversive stimulus. However, when behavior is being maintained by aversive techniques, conditioned suppression does not occur in the presence of a pre-aversive stimulus, but rather a conditioned response facilitation develops.

Sidman, Herrnstein and Conrad (1957) trained Rhesus monkeys on a 20" response-shock/shock-shock Sidman avoidance schedule. In such a schedule electric shocks are delivered to the animal every 20 seconds (shock-shock), but if a response occurs, the shock is delayed for 20 seconds from the time of the last response (response-shock). When a stable rate developed, 5 minute periods of straight avoidance were followed by a 5 minute period of a clicker which was terminated by an unavoidable shock. These periods alternated throughout the experimental session, and the avoidance contingency was maintained during the 5 minute stimulus period. They report:

> Superimposing the pairing of stimulus plus free-shock upon the avoidance baseline

> produced approximately a three-fold increase in response rate. The rate continued to increase for several hours and then began a slow decline (Sidman, *et al*, 1957, p. 554).

When the avoidance response was allowed to undergo extinction and the stimulus-shock retained, there was almost complete extinction during the 5 minute no-clicker period and the rate was definitely higher during the stimulus period followed by shock. Sidman *et al* (1957) explained the resistance to extinction as follows:

> The greater resistance to extinction of the avoidance response during the warning stimulus seems amenable to an explanation in terms of superstitously maintained avoidance behavior. In the absence of the stimulus, shocks are never received and the avoidance response extinguishes normally. In the presence of the stimulus, the shocks...(are delivered)...at varying intervals following a response. On the basis of the spurious response-shock contingencies, avoidance responding might be maintained by the free-shock, under the discriminative control of the warning stimulus. Since the spurious contingency occurs at a constant time interval discriminative control is eventually taken over by temporal factors, based upon the fixed 5 minutes stimulus-shock interval, and finally by the 10 minute shock-shock interval (p. 557).

In later studies Sidman (1958) attempted to produce response suppression and response facilitation in a single organism. Monkeys were trained in a situation where responses on one bar in the experimental chamber produced a pellet of food every 4 minutes on the average (VI-4'); responses on another bar would postpone shock for 20 seconds (Sidman avoidance). He found that the avoidance contingency exercised considerable control over the food-reinforcement bar. While the avoidance contingency was still in effect, there was considerable responding on the food bar even though no food was being delivered. When the avoidance behavior was extinguished, there was a low intermediate response rate on the food-bar approximating a typical variable interval rate. When both schedules were in effect, a pre-aversive stimulus produced response facilitation on both the food-and avoidance-bars. A chain pulling response for food was substituted for the bar, and there was still response facilitation of the food-reinforced response in the presence of the pre-shock stimulus. However when the VI schedule was changed to a FR schedule, he reported.

> ...the curve for the chain-pulling response... displays the alternating high rates and post reinforcement pauses characteristic of fixed-ratio behavior....In the presence of the stimuli, the rate of chain-pulling is close to zero. (Temporal conditioning may also be observed in that suppression actually begins prior to the stimulus). On the avoidance lever, in contrast, the response rate during the stimulus is considerably higher than between stimuli, though there is evidence of suppression even in the response just prior to the shocks (p. 277).

In a previously cited study, Sidman *et al* (1957) reported that conditioned facilitation of an avoidance response was a transitory phenomenon. That is, the immediate effect of the stimulus-shock pairings produced a general increase in avoidance responding, which was followed by a phase during which the rate of responding during the pre-aversive stimulus was considerably higher than in the absence of the stimulus. After many hours of exposure to this situation, the rate during the pre-aversive stimulus was approximately the same as in the absence of the stimulus.

However this adaptation of the effect of a pre-aversive stimulus has not been consistently reported. Waller and Waller (1963), for example, trained dogs on a multiple schedule. In the presence of one stimulus the dog received food reinforcement on a VI-1' schedule; in the presence of ~~a second stimulus (S-delta) responses were never reinforced;~~ and in the presence of a third stimulus responses postponed the occurrence of electric shock for 20 seconds (Sidman avoidance). When stimulus control was complete on all three of the components, the pre-aversive stimulus-shock pairs were introduced using a one-minute buzzer as the stimulus. During the first session of the stimulus-shock, the effect on the animal's behavior was rather dramatic. The subject received one stimulus-shock trial during the food-reinforcement component. The second trial occurred during the S-delta component and the animal began to respond when the buzzer came on and ceased responding after the shock. Likewise during the avoidance component, there was clearly an increase in avoidance responding correlated with the presence of the pre-aversive stimulus. During the VI component, the stimulus-shock pairing had no consistent effect on the organism's behavior during the stimulus period. The relatively high response rate generated by such a short VI schedule may have obscured any response facilitation which might have been in the records (Waller & Waller, 1963, p. 36). On the other hand, an overall effect of the stimulus-shock pairings on the VI component was to decrease the response rate, but the decrease was not specifically correlated with the occurrence of the pre-aversive stimulus.

Another interesting facet of this study was the effect of the stimulus-shock pairing when the avoidance component was permitted to undergo extinction. The stimulus-shock pairing was discontinued and the avoidance response was extinguished. When extinction was complete, the stimulus-shock pairings were re-introduced on the VI component. When the discriminative stimulus associated with the avoidance component occurred, the animal immediately began to emit avoidance responses and continued to do so for the duration of the component. After ten sessions of the avoidance extinction and stimulus-shock pairings, the subject continued to emit avoidance responses during the pre-aversive stimulus.

Related Studies

If it is true that the pre-aversive stimulus has a disruptive or facilitative effect upon human behavior, then it would be desirable to establish some physiological correlates of this phenomena through the use of skin surface electrodes and associated recording equipment. Several studies (Elliott, 1964; Frazier, 1964) performed at the National Aeronautics and Space Administration Manned Spacecraft Center, Houston, Texas, have shown that heart rate (expressed in number of beats per minute), and basal skin resistance were sensitive to changes in "arousal" level.

These studies were performed to attempt to cast light upon the relationship between physiological "arousal" measures and operant behavior while performing in a stressful situation, i.e., avoidance of electric shock. Frazier (1964) and Elliott (1964) presented data comparing behavioral and physiological responses of subjects who performed three two-hour trials on a vigilance task not involving aversive stimulation with three two-hour trials performing the same task but with an avoidance component. As compared to the trials without the avoidance contingency, the trials where electric-shock was "available" showed higher observing rates which resulted in the subjects detecting a greater proportion of the signals. The physiological data, however, suggested that there was a greater physiological cost during the shock contingency trials even though subjects received very few shocks during a given trial.

Additional subjects have been studied using the same vigilance task with a stimulus being associated with periods when the subject would be shocked for missing a signal; in the absence of this stimulus there would be consequence for failure to detect a signal. For example, a subject is given a 15-minute no-stimulus ("safe") period followed by a 15-minute stimulus ("not-safe") period. In this situation there were clear and consistent changes associated with the presence or absence of the stimulus.

Theoretical Considerations

~~Several theories have been postulated to account for~~ behavioral changes which occur in the presence of a pre-aversive stimulus. Since the noxious stimulus which is delivered is not correlated with a specific response on the part of the subject, such changes should be theoretically explainable in terms which do not involve a correlation between a response and the occurrence of the aversive stimulus. Church (1963), in an exhaustive treatment of the effects of punishment on behavior, summarized four such theories.

Fear Hypothesis. The first is the fear hypothesis which emphasizes,

> the importance of the unconditioned fear response elicited by the punishment that, by the principles of classical conditioning, may occur to the discriminative stimuli or to the response-produced stimuli (p. 372).

Thus the fear hypothesis asserts the importance of the emotional responses elicited by the punishment which may tend to "immobilize" the subject, thereby accounting for response suppression of operant behavior. There may be some justification for including a "fear" component in behavior during a pre-aversive stimulus; but, as mentioned previously, there are instances where operant behavior is facilitated in the presence of the pre-aversive stimulus. It would appear that fear alone cannot account for both response suppression and response facilitation.

Competing Response Hypothesis. The second theory, the competing response hypothesis, is strikingly similar to the first; it emphasizes:

> the importance of the unconditioned skeletal responses elicited by the punishment that, by the principles of classical conditioning, may occur to the discriminative stimuli or to the response-produced stimuli....Thus if the responses elicited by the aversive stimulus are incompatible with the punished act, punishment will suppress the act; but if the responses elicited by the aversive stimulus are similar to the punished act, punishment may facilitate the act (p. 373).

This theory does attempt to account for both response facilitation and suppression.

Escape Hypothesis. The third theory is the escape hypothesis which emphasizes;

> the importance of the response that resulted in escape from punishment that, by the principle of generalization, may occur to the discriminative stimuli or to the response-produced stimuli (p. 373).

Thus the escape hypothesis would predict that whatever behavior the organism happened to be engaged in at the time the aversive stimulus was terminated would be adventitiously strengthened. Since, at any given time, the animal is either pressing the bar or he is not pressing the bar, then it would appear that either response facilitation or response suppression could occur through "accidental" or superstitious learning. The experimental data are too orderly and consistent to tolerate such a hypothesis.

Discrimination Hypothesis. The fourth theory, the discrimination hypothesis, emphasizes:

> the similarity between the conditions of punishment procedure is considered as a response-produced cue with the same functions as non-aversive stimuli following a response. If punishment reinstates a condition of training it may facilitate the response; if punishment results in a change from the conditions of training a generalization decrement should be observed (p. 373).

This theory is a parsimonious explanation of several phenomena observed in punishment studies. For example, Appel (1960) demonstrated that monkeys, trained to postpone shock in the presence of one stimulus, increased their lever-pressing rate in the presence of another stimulus correlated with punishment-extinction. On the other hand, the discrimination hypothesis does not adequately account for the behavioral suppression or facilitation in the presence of a pre-aversive stimulus terminated by unavoidable shock. In all fairness, however, when Church refers to punishment, he means a noxious stimulus presented contingent upon a response (Church, 1963, p. 370).

<u>Generalization Hypothesis</u>. In view of the consistent, diametrically opposed effects of superimposing the pre-aversive stimulus-shock procedure upon behavior maintained by either a schedule of positive reinforcement or behavior maintained by avoidance schedules, a single unified theoretical interpretation may be presumptuous at the present time. Suffice to say, however, that the pre-aversive stimulus ~~acquires conditioned aversive properties of its own through~~ repeated pairing with the unconditioned aversive stimulus. This being the case, a form of a generalization (or induction) hypothesis may prove fruitful in accounting for both response facilitation and response suppression in this situation.

In support of a generalization hypothesis, consider a rat whose behavior is being maintained on a schedule of positive reinforcement. At the first presentation of the pre-aversive stimulus there is no noticeable effect on his behavior. When the unavoidable shock is delivered, the rat's ongoing behavior is disrupted by eliciting various unconditioned reflexes which normally follow painful stimulation, e.g., urination, defecation, violent skeletal muscle contraction produced by the electric shock, and perhaps other autonomic activities not directly observable. Of course, the shock may serve as a discriminative stimulus to emit other operants which may exist at some strength due to having been reinforced in the prior history of the rat exposed to other noxious situations. Nevertheless on subsequent presentations the pre-aversive stimulus acquires aversive properties similar to those of the unconditioned noxious stimulus. Following the time course of classical conditioning, the pre-aversive stimulus, through "internalized" response generalization, elicits responses similar to those of the unconditioned aversive stimulus. The unavoidable shock at the termination of the pre-aversive stimulus serves to maintain the conditioned reflexes at some strength. Thus the disruption associated with the unconditioned stimulus generalizes to the conditioned aversive stimulus resulting in suppression of the operant response.

Now in the case of avoidance, consider a rat during training on a Sidman-avoidance schedule with a shock-shock interval of 20 seconds and a response-shock interval also of 20 seconds (avoid SS 20" RS 20"). During the first few sessions of training, the rat receives numerous shocks before he learns the temporal discrimination associated with shock avoidance. The unconditioned aversive stimulus also elicits the same type of reflexes as in the case of the rat on the positive reinforcement as stated above. Nevertheless, in due course a temporal discrimination is learned in which the passage of time becomes aversive (Sidman, 1953).

An avoidance response postpones the shock which reduces the aversiveness by a finite amount. The avoidance response finally weakens in strength (extinguishes) until 20 seconds are allowed to elapse without making a response and the rat receives the primary aversive stimulus. The shock serves to reinstate the aversive properties of the temporal discrimination pattern and to elicit the unconditioned reflexes associated with electric shock. The aversive qualities of the temporal discrimination serve as cues for emitting the avoidance response. The first time the pre-aversive stimulus-shock is presented, little or no effect is noticed on the rat's behavior during the pre-aversive stimulus. The shock at its termination, however, again serves to reinstate the aversive properties of the temporal discrimination. Upon repeated presentation of the stimulus-shock, the pre-aversive stimulus assumes aversive properties similar to the qualities of the aversive schedule by which behavior is maintained. The passage of time becomes aversive and serves as a cue to emit the avoidance response; thus accounting for the facilitation of the avoidance response.

The response generalization hypothesis does attempt to account for both response suppression and response facilitation without invoking any new or ambiguous concepts, nor disregarding previously established principles of behavior. Other theories attempting to account for response facilitation and suppression usually are concerned with the punishment procedure, i.e., a noxious stimulus contingent upon the occurrence of a response. The generalization hypothesis, on the other hand, does not involve any correlation between the operant response and the occurrence of the primary aversive stimulus. However, the generalization hypothesis may be unique to the pre-aversive stimulus-shock situation.

CHAPTER III

METHOD AND PROCEDURE

Subjects

The subjects in this study were 20 young, healthy male college students. Eighteen of the subjects were from the University of Houston and 2 subjects were from Texas Southern University. Subjects were chosen from a list of students gathered from the University of Houston Placement Center, dormitories and from the Dean of Students of Texas Southern University; all subjects had volunteered to participate in a "psychophysical" experiment being conducted at the National Aeronautics and Space Administration, Manned Spacecraft Center.

Apparatus

The experimental chamber was a small sound attenuated chamber which measured approximately 4-feet wide by 8-feet deep by 6-feet high. A comfortable recliner chair was provided for the subject.. An instrument panel containing three 3-inch diameter DC voltmeters covered by one-way mirrors, three push-button observing keys, and three detection switches was conveniently situated in front of the recliner chair. The panel could be adjusted to accommodate each subject.

The behavioral programming apparatus consisted of a series of relay networks, electronic timers, tape programmers, and stepping switches. The behavioral data were recorded on a digital print-out counter which was programmed to print once each minute.

Basal skin resistance was continuously recorded on an Offner Type RS Dynograph strip chart recorder. Heart rate was recorded in digital form through the use of an amplifier and a current-sensitive relay. The electrocardiograph signal from the subject was amplified and passed to the current-sensitive relay which furnished a switch closure at every occurrence of the R-wave of the QRS complex of the electrocardiograph signal. The relay contact closure was routed to one channel of a print-out counter which was programmed to print each minute.

Subject Preparation

Subjects were dressed in gym-trunks to facilitate the application of the various skin surface electrodes. A pair of electrocardiograph electrodes was placed at the apex and base of the sternum. The location was used to minimize movement artifact in the signal due to movement by the subject. Basal skin resistance electrodes were applied to the upper calf of the right leg and on the inside of the right foot just below and slightly to the rear of the ankle bone. The shock electrodes were placed across the upper calf of the left leg. All electrodes were 2 square centimeter silver silver-cloride plated electrodes and were filled with a highly conductive sodium cloride base electrode paste. All electrode sites were shaved and thoroughly cleaned with acetone to remove the natural body oils.

The subject was placed in the experimental chamber and the electrodes were attached to the external recording and shock dispensing apparatus.

Procedure

The 20 Ss were randomly assigned to two groups. The first group of 10 Ss was the Avoidance Group, and the other 10 Ss were the Positive Reinforcement Group. Both groups performed essentially the same task but with one modification which will be explained below. The task was similar to one utilized by Holland (1958) in his study of human vigilance. The subject had to depress one of three switches which illuminated one of the corresponding meters for 100 msec., and was to report pointer deflections, or signals by means of one of three telever switches. If the correct telever switch was closed, the pointer returned to its zero position. Signals were randomly presented across the three meters and were programmed to occur on the average of one every two minutes (VI-2').

Each subject performed the task for two continuous hours. A 5-clicks per second clicker mounted in the chamber served as the pre-aversive stimulus. The pre-aversive stimulus was presented at the beginning of the 30th minute of the session and terminated at the end of the minute. When the pre-aversive stimulus ceased a 13 ma AC electric shock was delivered for a duration of 150 msec. The shock unit was a standard Grason-Stadler constant-current AC shock generator. The same shock intensity was used for all subjects. Nine minutes after the shock following the pre-aversive stimulus, the pre-aversive stimulus was again presented for one minute followed by electric shock. This temporal presentation of pre-averisve stimulus-shock was repeated until the end of the session. Thus there were 10 pre-aversive stimulus trials for each subject.

Avoidance Group. The Ss in this group were informed that failure to detect signals within a few seconds after its onset would result in a brief electric shock being delivered to their left leg, and if they made a proper detection response they could avoid receiving the shock. Each subject was thoroughly instructed as to the nature of the task, and was shown several signals on the meters and how to detect them. They were told that signals would occur randomly across the meters and randomly in time. Questions by the subject as to how long the pointers would stay deflected were answered by "not very long" or "just a few seconds". If the subject asked how frequently they were to observe the meters, he was told that it was up to him.

After the task was fully explained to the subject, he was told that at some time during the session he would hear a clicker which would stay on for a while and then go off, at which time he would receive an unavoidable shock to his left leg. He was told that the clicker-shock would be presented several times during the session, and that the avoidance task would be in effect during the time the clicker was on.

Each subject was permitted to practice the task without the shock contingency for a few minutes. When the experimenter was satisfied that the subject understood the task, the subject was allowed to rest for a few minutes, and the session was started.

The signals were presented on a VI-2' schedule and remained on for 5 seconds or until detected by the subject. Since the 5 second signal duration would permit Ss with a moderately high observing rate to successfully detect all the signals, it was assured that all subjects received at least two shocks prior to the first pre-aversive stimulus trial. The shock was of the same intensity and duration for failing to detect a signal as the pre-aversive stimulus-shock.

Each subject was paid 10 dollars for completing the session-- 6 dollars for the experimental session plus 4 dollars travel expenses.

<u>Positive Reinforcement Group</u>. The Ss in this group performed the same task as the Avoidance Group, but instead of receiving an electric shock for failing to detect a signal, they were told that they would receive 10 cents for each signal that was detected. An illuminated counter was mounted on top of the subject's panel. Each detection of a signal advanced the counter one unit with an audible "click" keeping the subject informed of how much money he had "earned". Each subject was thoroughly instructed as to the nature of the task and was shown several signals on the meters and how to detect them. They were told that signals would occur randomly across the meters and randomly in time, and he was to detect them as quickly as possible.

After the task was fully explained to the subject, he was informed about the occurrence of the pre-aversive stimulus and shock in the same manner as the Ss in the Avoidance Group. He was told that signals could occur during the pre-aversive stimulus.

Each subject was permitted to practice the task for a few minutes. When the experimenter was satisfied that the subject understood the task, the subject was allowed to rest for a few minutes and the session was started.

As in the Avoidance Group the signals were presented on a VI-2' schedule, but the signals' duration was 30 seconds.

This long signal duration was necessary to insure that a reinforcer would be delivered on a VI-2' schedule. These subjects were also paid 4 dollars travel expenses plus what they earned by detecting signals, and since all the signals were detected, they each received 10 dollars for their participation in the experiment.

CHAPTER IV

RESULTS

The findings of this study will be presented as follows: (a) Results on the behavioral data and (b) results on the physiological data.

Behavioral Data

Stability of Observing Response Rate.

The stability of the observing response rate, which was used as the dependent variable, is of major importance. Observing response rate stability was determined by the following procedure. The response rate/minute was found for minutes 14 through 21 and 22 through 29 of the experimental session for each of the 20 Ss. (These data are shown in Table 1.) These two rates were for the 16 minutes prior to the first pre-aversive stimulus trial, and were used in computing a Spearman rank-order correlation coefficient for each group and for the combined 20 Ss. The correlations were $r = .96$ for the Avoidance Group, $r = .88$ for the Positive Reinforcement Group and $r = .93$ for the combined 20 Ss. The first 13 minutes were not used in this analysis in order to allow the Ss to gain some familiarity in operating the test panel. The correlations and inspection of the data in Table 1 shows the response rates to be relatively stable. Subject P2 in the Positive Reinforcement Group increased his response

Table 1

Individual Observing Response Rate for Minutes 14 through 21 and the next 8 Minutes Prior to the First Pre-Aversive Stimulus for the Avoidance and Positive Reinforcement Groups

Avoidance Group			Positive Reinforcement Group		
S	Rate 14'-21'	Rate 22'-29'	S	Rate 14'-21'	Rate 22'-29'
A1	58.6	64.4	P1	105.3	105.9
A2	109.0	119.5	P2	119.1	219.0
A3	48.4	56.9	P3	66.6	99.5
A4	78.5	71.2	P4	65.3	62.0
A5	72.4	76.5	P5	79.5	87.6
A6	109.8	108.4	P6	53.2	57.6
A7	43.8	48.4	P7	98.2	97.8
A8	57.4	58.1	P8	73.4	74.8
A9	91.1	90.2	P9	91.5	94.2
A10	90.9	105.1	P10	60.5	65.2

rate approximately two-fold in the minutes just prior to the introduction of the first pre-aversive stimulus trial. This increase could not be related to any external stimulus. Subject P3 in the same group also showed a higher rate prior to the final pre-aversive stimulus trial.

Effect of the Pre-Aversive Stimulus on Response Rate.

In order to evaluate the effect of the pre-aversive stimulus on response rates, the response rate occurring in the pre-aversive stimulus period (one-minute) was compared to the rate/minute for the 8 minutes prior to its onset. Each subject's record was analyzed individually using the Wilcoxon signed-rank test (Dixon & Massey, 1957). The null hypothesis was that there would be no difference between the subject's observing rate in the presence of the pre-aversive stimulus and the rate/minute during the period prior to the onset of the pre-aversive stimulus. The results of these analyses will be discussed for each group separately.

Avoidance Group. Of the 10 Ss in this group, 5 exhibited significant changes in their observing rate during the pre-aversive stimulus. Four Ss increased and one S showed a suppression in their rate of response. The remaining 5 Ss failed to show significant changes. A summary of the analysis for the Avoidance Group is shown in Table 2.

Positive Reinforcement Group. Of the 10 Ss in this group, 5 exhibited significant changes in their observing

Table 2

Changes in Rate of Observing Responses for Each of the 10 Subjects in the Avoidance Group

Subject	Mean Change in Observing Rate	T[1]	N[2]	Significance Level (Two-Tail)
A1	-1.63	9	10	.06
A2	-4.66	14	10	NS
A3	+2.34	46	10	.06
A4	+5.20	52	10	.01
A5	+1.12	39	10	NS
A6	+4.41	51	10	.02
A7	+5.95	45	9	.01
A8	+2.53	38	10	NS
A9	+2.24	42	10	NS
A10	-2.38	9	9	NS

[1]T = Wilcoxon signed-rank test value.

[2]N = Number of trials with un-tied observations.

rate during the pre-aversive stimulus. Four Ss increased and one S showed a suppression in rate of response. The remaining 5 Ss did not show significant changes during the pre-aversive stimulus. A summary of the analysis for the Positive Reinforcement Group is shown in Table 3.

It is noted that the behavior exhibited by the Avoidance Group was similar to the observations made from lower animals (Sidman, 1958; Waller & Waller, 1963). That is, this group showed response facilitation in the presence of the pre-aversive stimulus. Four of the 5 Ss whose behavior changed significantly did show response facilitation during the pre-aversive stimulus while only one showed a suppression in response rate.

On the other hand, the Positive Reinforcement Group exhibited behavior that was diametrically opposed to the findings with lower animals. With lower animals whose behavior is being maintained by positive reinforcement, the introduction of a pre-aversive stimulus always results in a suppression of the rate of response (Estes & Skinner, 1941). However, in the present study the results for the Positive Reinforcement Group were exactly the same as the results of the Avoidance Group. Four subjects showed a significant increase in their rate of response during the pre-aversive stimulus while only one subject showed a significant decrease in response rate during the pre-aversive stimulus.

Table 3

Changes in Rate of Observing Responses for Each of the 10 Subjects in the Positive Reinforcement Group

Subject	Mean Change in Observing Rate	T[1]	N[2]	Significance Level (Two-Tail)
P1	+13.23	55	10	.01
P2	+ 7.86	35	10	NS
P3	-18.71	0	10	.01
P4	- 2.30	37	10	NS
P5	+80.44	52	10	.01
P6	- .70	19	10	NS
P7	+10.51	49	10	.03
P8	+ 4.30	44	9	.01
P9	- 3.30	21	10	NS
P10	- 2.65	12	10	NS

[1] T = Wilcoxon signed-rank test value.

[2] N = Number of trials with un-tied observations.

Additional Benavioral Results.

In order to evaluate the effect of the pre-aversive stimulus-shock upon the subjects' observing rate, a mean and standard deviation (S.D.) of each subject's observing rate/minute was determined for the first 21 minutes of the experimental session. These values were used as "base-line" measures which were compared with the rate and S.D.s occurring between the pre-aversive stimulus trials. In addition, a mean and S.D. of observing rate/minute for each subject was found for the minutes preceding the 10 pre-aversive stimulus trials. The responses occurring during the minute after each pre-aversive stimulus shock trial were omitted from the analysis in order to exclude any variance due to the shock. Thus these rates and S.D.s are based upon the 80 minutes occurring between the pre-aversive stimulus trials. These data are shown in Table 4 for the Avoidance Group, and in Table 5 for the Positive Reinforcement Group.

For each group the amount of change in observing response rate from the first 21 minutes of the experimental session and the 80 minutes between the pre-aversive stimulus trials was tested by the Wilcoxon signed-rank test. The Avoidance Group did not show any significant change in either their means or S.D.s, although there was a tendency toward an increase in both the means and S.D.s. On the other hand,

Table 4

Means and Standard Deviations for the First 21 Minutes and the Minutes Between the 10 Pre-Aversive Stimulus Trials for the Avoidance Group

S	First 21 Minutes Mean	First 21 Minutes S.D.	80 Minutes Between the Stimuli Mean	80 Minutes Between the Stimuli S.D.
A1	46.3	15.32	72.3	4.89
A2	102.9	10.60	90.0	20.82
A3	50.0	4.86	70.7	9.13
A4	74.0	7.66	84.9	11.01
A5	76.6	10.46	75.6	5.75
A6	105.7	6.25	97.1	14.12
A7	47.3	5.44	61.2	6.83
A8	49.8	7.67	57.3	11.76
A9	87.3	6.18	92.9	5.48
A10	84.3	8.44	127.6	14.07

Table 5

Means and Standard Deviations for the First 21 Minutes and the Minutes Between the 10 Pre-Aversive Stimulus Trials for the Positive Reinforcement Group

S	First 21 Minutes Mean	First 21 Minutes S.D.	80 Minutes Between the Stimuli Mean	80 Minutes Between the Stimuli S.D.
P1	100.1	6.55	130.4	16.64
P2	99.4	39.62	204.0	22.12
P3	64.3	6.64	91.1	17.06
P4	64.8	6.85	73.0	9.98
P5	72.6	19.01	136.8	42.88
P6	51.8	5.35	64.3	6.94
P7	94.9	10.02	96.6	23.77
P8	73.6	3.87	88.2	8.40
P9	84.5	9.85	116.4	13.30
P10	59.5	2.73	91.2	14.85

the Positive Reinforcement Group showed significant increases in means ($p \leq .01$) and S.D.s ($p \leq .06$) from the first 21 minutes of the session. Every S's rate was higher for the 80 minutes between the pre-aversive stimuli, and only one S showed a decrease in variability.

The difference between the two groups was evaluated by the use of the Mann-Whitney U test (Siegel, 1956). This test was performed on the means and S.D.s with the following results. For the first 21 minutes of the session, there was no significant differences between the two groups in either their means ($U = 46$) or their S.D.s ($U = 47$). However when the same test was performed on the means and S.D.s for the 80 minutes between the pre-aversive stimulus trials, there was a difference between the groups. The Positive Reinforcement Group had significantly higher means ($U = 27$, $p \leq .10$, two-tail) and significantly higher S.D.s ($U = 23$, $p \leq .05$, two tail) that did the Avoidance Group.

From the above analyses it is evident that the introduction of the pre-aversive stimulus-shock had more of a general facilitative effect on the overall response rate in the Positive Reinforcement Group than in the Avoidance Group. This would indicate some loss of the behavioral control attributable to the positive reinforcement schedule.

The Mann-Whitney U test of the differences in means and S.D.s from the first 21 minutes of the session to the

80 minutes between the pre-aversive stimulus trials was also performed for only the 10 Ss who showed significant changes in response rate during the pre-aversive stimuli. There were no indications that subjects who showed significant changes in response rate during the pre-aversive stimulus changed more, in either means ($U = 47$) or S.D.s ($U = 35$), than did the subjects whose changes were not significant.

Physiological Results

Basal skin resistance (BSR) and heart rate/minute were continuously monitored for all subjects to evaluate whether these physiological measures could yield additional information with respect to operant behavior.

Basal Skin Resistance.

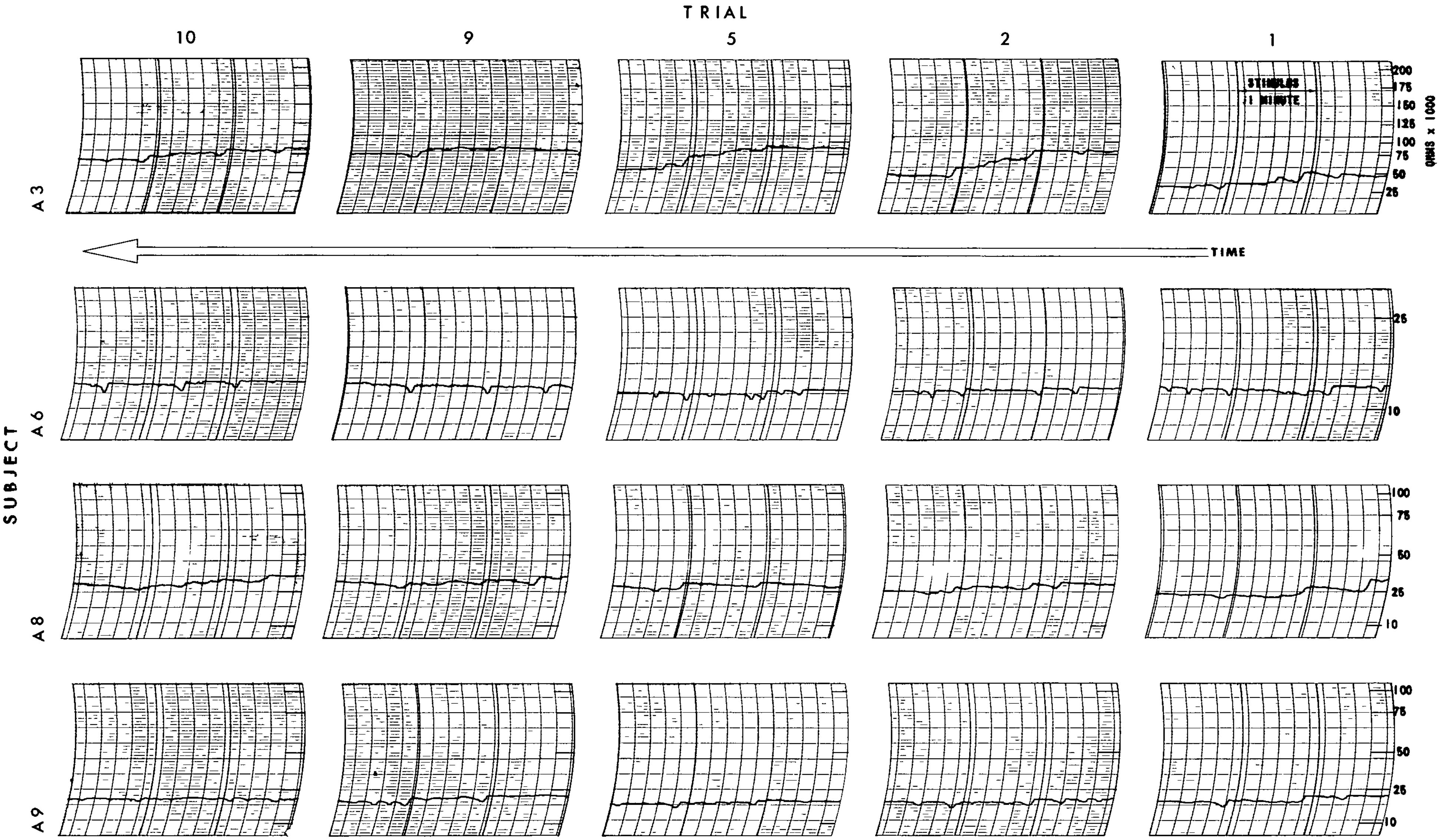
This measure has been generally accepted as an index of "arousal", low resistance indicating high arousal and high resistance indicating low arousal.

Avoidance Group. The BSR data for this group was generally low throughout the entire experimental session. Since BSR has a relatively long "recovery" time, the pre-aversive stimulus was not capable of further attenuating the skin potential. In a few subjects there was some increase in resistance between the pre-aversive stimulus trials, but these changes were slight. These relatively low skin resistance values may be taken as an indirect index of the "aversiveness" of the task. Several representative records for this group are shown in Figure 1.

<u>Positive Reinforcement Group</u>. Most of the subjects in this group showed rather large initial decreases in skin resistance at the onset of the first pre-aversive stimulus and skin resistance was further attenuated by the shock. There was some increase in resistance between the pre-aversive stimulus trials, but in most cases it did not recover to the level of the preceding trial. In this group there were a number of subjects who showed rather low resistance values throughout the entire session, and particularly after the first shock. Several representative records for this group are shown in Figure 2.

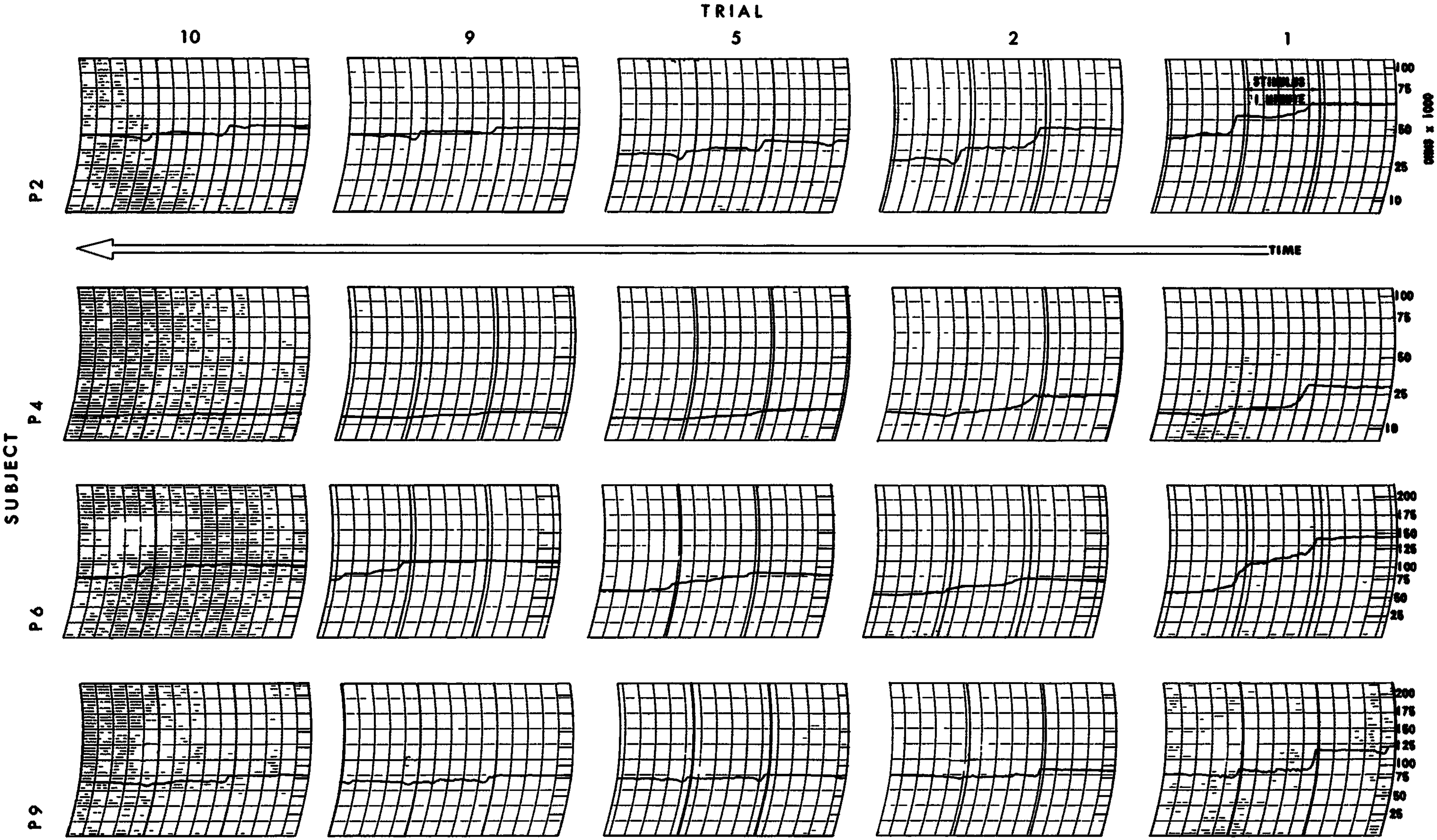
<u>Heart Rate</u>.

Heart rate changes have also been taken as indicative of a changed state of "arousal". In this study a count of the number of heart beats occurring each minute was recorded for each subject during the entire experimental session. The data were analyzed in the same way as the observing responses. That is, the beats/minute occurring in the presence of the pre-aversive stimulus were compared with the beats/minute for the 8 minutes prior to its onset. Each subject's record was analyzed individually using the Wilcoxon signed-rank test.



THE EFFECTS OF THE PRE AVERSIVE STIMULUS ON BASAL SKIN RESISTANCE FOR FOUR SUBJECTS IN THE AVOIDANCE GROUP

FIGURE I



THE EFFECTS OF THE PRE AVERSIVE STIMULUS ON BASAL SKIN RESISTANCE FOR FOUR SUBJECTS IN THE POSITIVE REINFORCEMENT GROUP

FIGURE 2

Avoidance Group. Seven of the 10 Ss in this group showed significant increases in heart rate during the pre-aversive stimulus, and 3 Ss did not show significant changes. A summary of these analyses is shown in Table 6.

Positive Reinforcement Group. Nine of the 10 Ss in this group showed significant increases in heart rate during the pre-aversive stimulus. Only one subject failed to exhibit a significant increase during the pre-aversive stimulus. Table 7 shows a summary of these analyses.

Differences Between Groups. Several analyses were performed for the purpose of revealing the differential effect that the pre-aversive stimulus had upon the subject's heart rate. The first analysis was to see if there was a significant difference between the two groups prior to the first pre-aversive stimulus trial. A Mann-Whitney U test was performed on the heart rate for the 8 minutes prior to the presentation of the pre-aversive stimulus trial. These data for the Avoidance Group and for the Positive Reinforcement Group are shown in Tables 8 and 9 respectively. The results of this analysis revealed that the subjects in the Avoidance Group generally had a higher heart rate than the Positive Reinforcement Group as would be expected, but their heart rate was not significantly higher ($U = 31$).

On the other hand, when a "lability" index was determined by taking the percentage differences between the

Table 6

Changes in Heart Rate for Each of the 10 Subjects in the Avoidance Group

S	Mean Percent Change in Heart Rate	T[1]	N[2]	Significance Level (Two-Tail)
A1	10.5	55	10	.01
A2	2.0	30	10	NS
A3	6.7	55	10	.01
A4	.5	27	10	NS
A5	4.7	53	10	.01
A6	4.1	45	9	.01
A7	14.6	55	10	.01
A8	.3	27	10	NS
A9	10.2	55	10	.01
A10	5.5	45	9	.01

[1]T = Wilcoxon signed-rank test value.

[2]N = Number of Trials with un-tied observations.

Table 7

Changes in Heart Rate for Each of the 10 Subjects in the Positive Reinforcement Group

S	Mean Percent Change in Heart Rate	T[1]	N[2]	Significance Level (Two-Tail)
P1	12.6	55	10	.01
P2	15.8	55	10	.01
P3	8.8	55	10	.01
P4	14.4	54	10	.01
P5	26.8	55	10	.01
P6	3.2	46	10	.01
P7	19.6	55	10	.01
P8	22.3	55	10	.01
P9	1.0	34	10	NS
P10	11.9	55	10	.01

[1]T = Wilcoxon signed-rank test value.

[2]N = Number of Trials with un-tied observations.

Table 8

The Heart Rate/Minute for Eight Minutes Prior to the First Pre-Aversive Stimulus and the Rate/Minute During the First Trial of the Pre-Aversive Stimulus for the Avoidance Group

S	Rate/Min. Trial 1	Rate/Min. Prior to Trial 1	Diff.	Percent Diff.
A1	107	87.2	+19.8	+23
A2	97	90.8	+ 6.2	+07
A3	78	73.5	+ 4.5	+06
A4	118	119.0	- 1.0	-01
A5	86	77.4	+ 8.6	+11
A6	148	135.2	+12.8	+09
A7	87	69.5	+17.5	+27
A8	98	91.4	+ 6.6	+07
A9	95	84.5	+10.5	+12
A10	93	87.8	+ 5.2	+06

Table 9

The Heart Rate/Minute for the Eight Minutes Prior to the First Pre-Aversive Stimulus and Rate/Minute During the First Trial of the Pre-Aversive Stimulus for the Positive Reinforcement Group

S	Rate/Min. Trial 1	Rate/Min. Prior to Trial 1	Diff.	Percent Diff.
P1	98	80.6	+17.4	22
P2	135	106.9	+28.1	26
P3	98	82.8	+15.2	18
P4	70	59.8	+10.2	17
P5	96	82.8	+13.2	16
P6	97	82.8	+14.2	17
P7	107	84.9	+22.1	26
P8	103	86.8	+16.2	19
P9	79	81.8	- 2.8	-02
P10	73	59.8	+13.2	22

heart rate that occurred during the first pre-aversive stimulus trial and the rate/minute for 8 minutes prior to the first trial, there was a significant difference between the two groups. The Mann-Whitney U test showed that the Positive Reinforcement Group exhibited a significantly higher increase ($U = 26$, $p \leq .10$, two-tail) than did the Avoidance Group. These differences were also significant when the average percentage of the changes for all 10 trials were considered ($U = 21$, $p \leq .05$, two-tail). These data are shown in Table 10 for both groups.

The Mann-Whitney U test was also performed on the average percentage change in heart rate comparing the 10 Ss who showed significant changes in observing response rate during the pre-aversive stimulus versus the 10 Ss who did not show significant differences in response rate during the pre-aversive stimulus. Although there was a tendency for the subjects who showed significant changes in response rate during the pre-aversive stimulus to have higher percentage increases in heart rate, they were not significantly higher ($U = 29$) than the 10 Ss who did not show significant changes in response rate.

From the above analyses it is evident that the pre-aversive stimulus had the effect of increasing the heart rate of the subjects in this study. These analyses also point out some of the difficulties encountered in attempting to

Table 10

Mean Percentage Increase in Heart Rate During the Ten Pre-Aversive Stimulus Trials for the Avoidance and Positive Reinforcement Groups

S	Avoidance Group Mean Percentage Change for 10 Trials	S	Positive Reinforcement Group Mean Percentage Change for 10 Trials
A1	10.5	P1	12.6
A2	2.0	P2	15.8
A3	6.7	P3	8.8
A4	.5	P4	14.4
A5	4.7	P5	26.8
A6	4.1	P6	3.2
A7	14.6	P7	19.6
A8	.3	P8	22.3
A9	10.2	P9	1.0
A10	5.5	P10	11.9

analyze "raw" heart rate data for comparison with other subjects or groups of subjects. The comparison of the "raw" rate/minute did not reveal any significant differences between the two groups, but the lability score did show that the Positive Reinforcement Group was significantly more labile than was the Avoidance Group.

CHAPTER V

DISCUSSION

There is little doubt that the pre-aversive stimulus-shock combination had significant effects on the subject's behavior in both the Avoidance Group and the Positive Reinforcement Group. In some cases the effect was dramatic and in others the effect was rather subtle. In the case of some of the subjects who did not show reliable behavioral changes across trials, there were, nevertheless, some considerable behavioral changes during the pre-aversive stimulus; however since the changes were not consistent from trial to trial, their behavior cannot be interpreted with any degree of confidence or parsimony.

With respect to the use of observing response rate as a reliable measure of behavior, the relatively high correlations obtained between the two 8 minute periods before the first pre-aversive stimulus trial indicate that the observing response rate was a reliable behavioral measure in spite of the variability contained in the observing response.

In the case of the subjects performing on the avoidance schedule, the data of this study give general confirmation of response facilitation during a pre-aversive stimulus. As with animals, this response facilitation does not "gain" anything for the subject in that the avoidance behavior does not reduce the probability of receiving the unavoidable shock.

The subjects in the Positive Reinforcement Group performed in the same general manner as did those in the Avoidance Group by showing response facilitation during the pre-aversive stimulus. These results are in direct opposition to the response suppression phenomenon in the presence of a pre-aversive stimulus which is systematically observed in lower animals that are responding for positive reinforcement.

One explanation for the results of the Positive Reinforcement Group involves the "adequacy" of money to be effective as a reinforcer. This question is important in respect to the degree of behavioral control which the schedule was able to exert on the subjects' behavior. In view of the significant increases in the overall response rate and variance for the Positive Reinforcement Group, it is quite likely that the pre-aversive stimulus-shock was instrumental in disrupting some of the control which had been established by the schedule. However, this explanation must remain speculative for the present.

Another explanation for the response facilitation in the Positive Reinforcement Group would be in terms of the reinforcement history of the subjects. Animals, for example, with an unextinguished avoidance history do not show conditioned suppression during a pre-aversive stimulus when transferred to a positive reinforcement schedule, but rather show a response facilitation during the pre-aversive stimulus. This effect was aptly demonstrated by Waller & Waller (1963) in a study with dogs. Their subjects were performing on a multiple positive reinforcement /S-delta/Sidman Avoidance/ S-delta schedule. The introduction of a pre-aversive stimulus followed by unavoidable shock resulted in a response facilitation on all components of the multiple schedule, even during the S-delta component where shock avoidance had not been previously associated with S-delta stimulus. During the first session where the pre-aversive stimulus-shock was introduced, two pre-aversive stimulus-shock trials were presented during the positive reinforcement component. The third trial occurred during the S-delta component and the animal began to respond almost immediately after the onset of the pre-aversive stimulus.

A study performed by Sidman (1958) is also relevant to this problem. He attempted to produce both response facilitation and response suppression in a monkey working on a concurrent positive reinforcement and avoidance schedule. He obtained some degree of success only after many abortive attempts. When both operants were bar-presses, he found that the avoidance schedule exercised considerable control over the positive reinforced bar and response rate increased on both response bars during the pre-aversive stimulus. Changing the topography and location of the positive reinforcement manipulandum (a chain-pull response suspended from the ceiling of the experimental chamber) also did not alter the results; again response rate increased during the pre-aversive stimulus. He was successful only after changing the original variable interval positive reinforcement schedule to a fixed interval schedule coupled with the chain-pull response.

Thus it is evident that the phenomenon of conditioned suppression and conditioned facilitation are not independent of the animal's history. It appears that the effect for a given animal is a function of the response that has the greatest strength in the behavioral repertory of the animal. If this is the case, then a tentative explanation for the response facilitation in the Positive Reinforcement Group is possible. Much of man's behavior is maintained by the employment of aversive techniques; thus many humans have a rather extensive history of unextinguished avoidance and escape behavior. The subjects in the Positive Reinforcement Group who did exhibit response facilitation during the pre-aversive stimulus could have had an unextinguished history of avoidance and escape responses which was present at some strength during the experimental session. The pre-aversive stimulus could have been a discriminative stimulus for emitting avoidance-like responses. However it should be noted that this hypothesis is not supported by direct evidence in this study.

The Avoidance Group, on the other hand, generally did substantiate the observations made from lower animals by showing response facilitation during the pre-aversive stimulus. The results from this group are amenable to the same interpretation for the response facilitation as the Positive Reinforcement Group, but with the added fact that they were given an immediate history of avoidance during the experimental session in addition to their previous unextinguished avoidance history.

One is at an immediate loss in explaining those subjects who did not show significant and reliable changes in their observing response rate during the pre-aversive stimulus. Nevertheless some of the subjects did show some rather large response rate changes during the pre-aversive stimulus, but the direction of these changes varied from trial to trial. It would have been interesting to have had additional experimental sessions with these subjects to see if their response rate during the pre-aversive stimulus would have developed into a stable suppression or facilitation.

The physiological results of this study did serve to point out some difficulties which are often encountered in the interpretation of data of this nature. This is particularly true of the heart rate data. There are considerable individual differences in "normal" heart rate among subjects due to several factors; among these are such things as the general physical condition of the subject, the initial "anxiety" level of the subject in response to the general testing situation, etc. That is, the "normal" heart rate for subject X might be considered "high" for subject Y. Subject Y's heart rate under a stressful condition may increase to a level comparable to Subject X (who is not under stress) and thereby show no essential differentiation between the two subjects. Now impose an additional amount of stress to Y and the same amount to X. It is then not reasonable to expect the heart rate of both subjects to increase in equal amounts. Since the heart rate of Y is being "pushed" to some extent by the initial level of stress, imposing additional stress will not add equal increments to both subjects' stress level as measured by their heart rate. Although this notion would be difficult to test empirically, the analysis of the lability of the heart rate does give some indirect evidence. When the heart rates of the Avoidance Group and the Positive Reinforcement Group were compared prior to the pre-aversive stimulus trials, the Avoidance Group showed higher heart rates than the Positive Reinforcement Group, but not significantly higher. However when the difference between the baseline heart rates and the heart rate during the first pre-aversive stimulus trial were compared, a significant difference was found to exist between the two groups. The subjects in the Positive Reinforcement Group showed a greater percentage increase in their heart rate than did the subjects in the Avoidance Group during the first pre-aversive stimulus trial. The subjects in the Positive Reinforcement Group were significantly higher than the Avoidance Group when the average percentage change was considered for all 10 pre-aversive stimulus trials.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this study was to evaluate the effects of a pre-aversive stimulus followed by unavoidable shock upon human behavior. Twenty paid valunteer male college students were used as subjects. Subjects were randomly assigned to two equal groups. Ten subjects were assigned to the Avoidance Group and 10 subjects were assigned to the Positive Reinforcement Group. Each subject performed on a vigilance task similar to the one described by Holland (1958); the experimental session was two hours for each subject.

The Avoidance Group monitored 3 meters by pressing 3 corresponding push-button switches. Meter deflections, or signals were presented on a two minute variable interval schedule (VI-2'). The signals remained on the meters for 5 seconds. If they were not detected within this time a 100 ma AC electric shock was delivered to the left leg of the subject for a duration of 150 msec.

The Positive Reinforcement Group performed the same task but without the shock contingency. Instead they received a dime for every signal detected. An illuminated counter on the subjects' console kept him informed as to the number of signals detected. Signals were presented on a VI-2' schedule, and remained for 30 seconds or until detected by the subject

Each of the subjects in both groups were permitted to work for 29 minutes and at the beginning of the 30th minute a pre-aversive stimulus (clicker) was presented. The pre-aversive stimulus remained on for one-minute and at the end of the minute it was terminated and an unavoidable electric shock was delivered to the subject. This procedure was repeated nine times making a total of 10 pre-aversive stimulus-shock trials.

Basal skin resistance and heart rate data were recorded continuously for all twenty subjects.

Four of the subjects in the Avoidance Group showed a significant increase in observing response rate during the pre-aversive stimulus and one subject showed a significant suppression in response rate. Five subjects did not exhibit reliable behavioral changes during the pre-aversive stimulus.

Likewise, 4 subjects in the Positive Reinforcement Group showed a significant increase in observing response rate during the pre-aversive stimulus and one subject showed a significant suppression in response rate. Five subjects did not exhibit reliable behavioral changes during the pre-aversive stimulus.

In view of these findings it was concluded that the response facilitation in both groups was most likely the result of an unextinguished avoidance and escape history of the subjects, and the pre-aversive stimulus acted as a discriminative stimulus for emitting avoidance-like responses which had been effective in avoiding or escaping noxious stimuli in the past.

The Basal skin resistance values were generally low for both groups and due to its relatively long recovery time it did not provide any useful information relative to the effects of the pre-aversive stimulus and operant behavior.

The heart rate data revealed that 7 subjects in the Avoidance Group and 9 in the Positive Reinforcement Group showed significant heart rate increases during the pre-aversive stimulus. Comparing the heart rates between the two groups revealed no significant differences between them before the pre-aversive stimulus trials although the subjects in the Avoidance Group had slightly higher rates. When the percentage increase in heart rate during the pre-aversive stimulus trials were compared, the Positive Reinforcement Group showed a significantly greater increase than the Avoidance Group on the first trial and also on the percentage increase on all 10 pre-aversive stimulus trials. It was concluded from these analyses that the Avoidance Group was under greater "stress" than the Positive Reinforcement Group due to the fact that the pre-aversive stimulus did not induce equal heart rate changes in the two groups. Thus it is hypothesized that increments in stress level results in non-linear increments in heart-rate. That is, equal increments in stress level will result in a negatively acclerated heart rate lability curve.

It goes without saying that additional experimentation needs to be done in order to further clarify the results of this study. It might be productive to attempt to relate certain personality traits to the phenomena of conditioned suppression or facilitation, or perhaps use this technique or some modification with different psychiatric diagnostic groups to evaluate changes in their behavior. In any case it behooves the psychologist to study human behavior before making cavalier extrapolations from animal studies.

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APPENDIX

Table 11

Observing Response Rate and Heart Rate Data for Subject A1[1]

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	64.37	66	87.25	107
2	68.00	66	87.25	102
3	71.37	71	86.50	98
4	72.00	69	87.00	96
5	74.50	70	86.50	88
6	73.62	75	86.75	97
7	72.37	70	84.75	87
8	72.50	73	82.75	90
9	74.50	70	82.87	93
10	81.00	78	81.37	85

[1]A = Avoidance Group.

Table 12

Observing Response Rate and Heart Rate

Data for Subject A2

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	119.50	93	90.75	97
2	81.50	61	91.50	94
3	76.50	70	92.25	92
4	82.12	84	94.37	101
5	87.87	78	95.87	94
6	90.00	81	94.12	94
7	96.00	85	95.12	93
8	82.87	103	93.50	96
9	96.37	99	95.50	94
10	106.87	116	95.87	102

Table 13

Observing Response Rate and Heart Rate

Data for Subject A3

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	56.88	60	73.5	78
2	61.62	62	74.5	86
3	61.12	62	73.62	83
4	66.38	69	74.25	77
5	69.25	75	72.50	77
6	72.12	78	71.12	74
7	76.12	80	70.00	72
8	79.25	76	69.75	71
9	78.00	83	69.38	71
10	85.88	85	70.25	76

Table 14

Observing Response Rate and Heart Rate

Data for Subject A4

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	71.25	85	119.00	118
2	74.38	81	117.88	116
3	75.00	80	114.75	113
4	87.00	91	112.88	117
5	89.62	93	110.62	110
6	89.62	98	108.25	108
7	83.38	94	105.25	105
8	97.38	96	108.00	110
9	93.5	92	106.75	106
10	87.88	91	99.37	102

Table 15

Observing Response Rate and Heart Rate

Data for Subject A5

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	76.5	80	77.38	86
2	76.62	70	82.25	86
3	75.75	80	86.88	97
4	79.38	82	89.88	93
5	73.50	74	90.12	92
6	72.50	79	89.38	91
7	74.88	74	89.38	90
8	76.25	78	87.38	95
9	75.38	73	90.25	89
10	76.00	78	85.50	88

Table 16

Observing Response Rate and Heart Rate
Data for Subject A6

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	108.38	117	135.75	148
2	115.88	120	136.00	136
3	116.00	118	129.75	137
4	105.88	105	127.12	130
5	96.12	102	130.38	134
6	91.00	99	126.88	135
7	87.38	97	126.88	135
8	87.88	93	126.75	129
9	82.38	80	123.12	127
10	80.00	84	126.25	131

Table 17

Observing Response Rate and Heart Rate

Data for Subject A7

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	48.38	53	69.50	87
2	53.12	62	76.62	79
3	59.75	62	67.88	80
4	64.00	64	68.38	75
5	60.00	64	62.75	73
6	63.62	71	62.88	71
7	62.38	65	58.75	66
8	65.62	73	59.25	67
9	68.62	82	57.00	66
10	67.00	76	56.00	66

Table 18

Observing Response Rate and Heart Rate

Data for Subject A8

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	58.12	65	91.38	98
2	62.50	60	91.50	90
3	61.25	73	89.25	91
4	67.25	72	86.50	87
5	68.50	63	84.00	82
6	48.25	60	83.75	82
7	49.50	66	81.38	81
8	51.38	28	81.00	79
9	45.37	53	78.88	77
10	54.62	52	76.75	79

Table 19

Observing Response Rate and Heart Rate

Data for Subject A9

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	90.25	90	84.50	95
2	93.75	87	86.25	98
3	90.00	102	86.50	97
4	89.75	88	90.62	108
5	94.50	98	90.75	101
6	93.62	96	89.25	94
7	90.00	91	87.50	94
8	91.12	102	88.12	92
9	95.12	96	85.50	92
10	100.50	106	87.12	96

Table 20

Observing Response Rate and Heart Rate

Data for Subject A10

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	105.12	95	87.75	93
2	113.12	112	89.50	100
3	113.00	113	93.75	104
4	122.38	117	94.12	102
5	127.38	127	93.38	98
6	134.38	128	94.88	97
7	132.12	134	92.62	95
8	136.38	140	92.37	100
9	147.88	147	93.12	94
10	144.00	139	92.00	92

Table 21

Observing Response Rate and Heart Rate

Data for Subject P1[1]

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	105.87	127	80.62	98
2	124.50	146	79.25	96
3	123.62	146	83.25	96
4	116.12	126	81.50	94
5	119.00	133	80.25	88
6	122.62	145	81.00	89
7	139.37	145	84.62	91
8	150.50	154	85.37	92
9	151.12	157	86.12	97
10	151.00	157	87.12	91

[1]P = Positive Reinforcement Group.

Table 22

Observing Response Rate and Heart Rate

Data for Subject P2

Trial	Observing Response /Min. Control Period	Observing Response /Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	219.00	168	106.87	135
2	213.12	241	105.87	132
3	217.87	214	108.50	137
4	210.00	199	112.25	135
5	215.75	203	116.00	130
6	180.24	199	118.00	132
7	188.25	213	119.87	133
8	177.00	210	119.25	131
9	194.00	240	119.25	130
10	205.12	212	119.00	127

Table 23

Observing Response Rate and Heart Rate

Data for Subject P3

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	99.50	93	82.75	98
2	88.62	79	81.12	93
3	94.50	77	82.62	93
4	82.75	68	80.25	87
5	92.62	75	80.38	80
6	124.25	65	80.38	87
7	76.38	65	78.12	86
8	83.38	65	79.75	84
9	88.75	75	81.88	92
10	79.38	61	83.88	90

Table 24

Observing Response Rate and Heart Rate

Data for Subject P4

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	62.00	70	59.75	70
2	78.88	71	57.38	67
3	82.12	73	58.62	69
4	82.00	94	60.33	75
5	71.12	58	61.38	74
6	67.75	58	62.12	70
7	60.25	59	63.38	72
8	79.75	85	63.00	67
9	76.25	68	64.00	72
10	78.88	80	64.5	65

Table 25

Observing Response Rate and Heart Rate

Data for Subject P5

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	87.62	89	82.75	96
2	101.75	111	81.00	107
3	102.75	137	82.12	112
4	149.12	276	90.37	124
5	176.25	165	92.50	122
6	162.00	209	92.87	121
7	162.12	300	93.00	116
8	120.25	326	90.12	112
9	139.50	245	92.25	107
10	177.00	326	93.75	113

Table 26

Observing Response Rate and Heart Rate

Data for Subject P6

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	57.62	61	82.75	97
2	58.37	61	83.38	86
3	61.00	59	82.38	85
4	60.12	57	80.75	82
5	60.62	62	79.00	81
6	63.87	63	78.62	82
7	67.25	63	78.75	76
8	68.50	67	78.50	78
9	72.00	71	76.75	78
10	73.62	72	76.38	78

Table 27

Observing Response Rate and Heart Rate

Data for Subject P7

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	97.75	102	84.88	107
2	105.00	106	85.12	109
3	111.12	109	91.62	118
4	107.38	103	98.37	118
5	108.00	118	98.50	119
6	100.75	126	100.75	111
7	109.38	117	100.00	115
8	75.12	125	95.50	113
9	84.38	94	96.00	109
10	80.00	84	95.12	110

Table 28

Observing Response Rate and Heart Rate

Data for Subject P8

	Observing Response/Min.		Heart Rate/Min.	
Trial	Control Period	Pre-Aversive Stimulus Period	Control Period	Pre-Aversive Stimulus Period
1	74.75	73	86.75	103
2	81.75	88	92.75	123
3	83.00	83	100.00	127
4	83.62	87	106.12	136
5	85.12	91	109.50	139
6	90.00	93	108.75	135
7	88.75	93	108.12	125
8	92.62	105	107.25	125
9	97.62	105	106.68	126
10	104.75	107	112.87	129

Table 29

Observing Response Rate and Heart Rate

Data for Subject P9

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	94.25	100	81.75	79
2	110.12	110	78.62	82
3	107.75	119	79.12	83
4	118.38	119	77.62	82
5	115.00	104	78.12	83
6	127.50	102	78.62	81
7	120.12	130	78.62	73
8	118.50	109	76.75	75
9	125.50	122	81.62	80
10	126.88	116	80.38	80

Table 30

Observing Response Rate and Heart Rate

Data for Subject P10

Trial	Observing Response/Min. Control Period	Observing Response/Min. Pre-Aversive Stimulus Period	Heart Rate/Min. Control Period	Heart Rate/Min. Pre-Aversive Stimulus Period
1	65.25	63	59.75	73
2	76.62	74	57.12	78
3	87.62	78	57.75	71
4	87.50	79	56.88	57
5	87.38	90	61.62	68
6	96.00	88	62.00	68
7	92.62	92	62.25	65
8	101.00	96	61.38	65
9	103.37	111	61.50	64
10	114.12	114	61.38	64