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Behavioral Interactions Under Noxious Environments

Annual Report

James E. Barrett

June 30, 1977

Supported by

U. S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
Washington, D. C. 20315

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Department of Psychology
University of Maryland
College Park, Maryland 20742

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Current behavior is affected not only by its immediate consequences but also by events that are temporally quite remote. Events that have occurred in the past, as well as conditions existing under different environmental contexts can often significantly influence ongoing behavior. Interactions between these many factors can result in unique outcomes that can only be understood when multiple determinants of behavior are considered. The primary emphasis of this research program has been on developing an understanding of the manner and extent to which an organism's previous history and current environmental setting determine the specific effects of noxious stimuli on behavior.

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Summary

Experiments conducted during the past year using squirrel monkeys have focused on an examination of experiential factors contributing to the development and ultimate maintenance of responding by response-produced noxious stimuli, and on features of the environment that subsequently modify this behavior. Related experiments have concentrated on analyses of behavioral interactions occurring under multiple schedules using noxious stimuli as the predominant controlling event. In these experiments, responding was maintained under separate conditions by the presentation of electric shock, by shock postponement (avoidance), or by the termination of stimuli correlated with shock (escape). Selected experiments have also examined interactions between these behaviors and punished behavior. When performances were stable, the consequences of responding were changed in one of the two conditions and the total effects on behavior assessed. Changes in the environmental consequences of behavior under one stimulus condition can markedly alter behavior occurring elsewhere, even though nothing in the latter condition has been modified. In addition to studying interactions between behaviors occurring sequentially, this program has also analyzed behaviors maintained simultaneously under concurrent schedules where, again, responding was typically controlled by noxious events. Significant changes occurred in one behavior due solely to the modification of consequences for a different response. These experiments have successfully developed and maintained a wide variety of stable and reproducible behaviors under the control of a single noxious event, electric shock. Further, they have demonstrated the sensitivity of these behaviors to multiple factors. The same noxious event can influence behavior in completely different ways depending on the organism's previous experience, on the manner in which it is scheduled, and on factors that exist in the total environmental context where the behavior occurs. An understanding of the manner in which current behavior is affected by noxious environmental events cannot be complete unless these many factors are taken into account.

Foreward

In conducting the research described in this report, the investigator adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences-National Research Council.

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Introduction

Environments in which noxious events occur are pervasive. Whether these events occur naturally, or whether they are more deliberately arranged, changes in behavior almost inevitably ensue. Quite often the same noxious event will affect behavior in markedly different ways, suggesting that behavior is subject to multiple influences. Although there has been a tendency to emphasize the immediate consequences of behavior, in many cases those factors that determine the effects of noxious stimuli are not present at the time behavior is modified. Instead, changes in current behavior can often more accurately reflect the significance of more remote factors than those existing in the immediate environmental setting.

This research program is directed towards an analysis of behaviors specifically controlled by noxious environmental events where features other than the more immediate consequences of behavior appear to exert an influential effect. Such behavioral interactions can theoretically derive from prior or coexisting influences, the organism's previous experience, events occurring elsewhere, or from other ongoing behaviors. Any one of these can profoundly modify the effects a noxious stimulus will have on behavior.

In those experiments summarized in this report, the major focus has been on investigating the potential interactions between behaviors occurring sequentially in time under separate environmental conditions (multiple schedules) and on behaviors that can occur simultaneously (concurrent schedules). A related, inseparable facet of this emphasis has been that of assessing the role of prior behavioral experience as a determinant of the effects of noxious stimuli. An experimental analysis of behavioral interactions under the conditions described here is essential for a thorough understanding of the manner in which emergent and established behavior is affected by noxious events.

Processes of Reinforcement and Punishment

Operant behavior is developed and controlled by its environmental consequences. Those events that follow behavior, whether they are presented or terminated, and result in a subsequent increase in the frequency of similar responses are called reinforcers. If the presentation or termination of some event following a particular response decreases the future occurrence of similar responses, the process of punishment has taken place and, in that situation, the consequent event can be referred to as a punisher. Reinforcement and punishment are empirical behavioral processes; the defining characteristics of reinforcers and punishers are not properties of the event but those changes that occur in behavior following their presentation.

There has been a tendency to overemphasize some presumed inherent quality of an event that makes an event a reinforcer or punisher. Usually, such properties were tacitly assumed to be immutable and "transituational;" an event which functioned as a reinforcer under one situation would also do so under others. There is now substantial evidence suggesting that these views are wrong and that the behavioral effects of many different events depend overwhelmingly on the circumstances under which they occur. A consequent event which punishes responding under one condition may function as an extremely effective reinforcer under another. The behavioral effects of events do not depend on the inherent properties of the events, but on other factors that have preceded and which currently accompany their presentation.

That events do not possess invariant properties can be illustrated by the work of Premack (1965; 1971). In one experiment, the relative probabilities of drinking and running were manipulated by restricting access to either a running wheel or to a bottle. When rats were deprived of running, the frequency of less probable drinking was increased (reinforced) when it resulted in access to the wheel. On the other hand, when rats were water deprived but allowed free access to the running wheel, water drinking was suppressed (punished) when it resulted in forced running in a motorized wheel. Thus, the same event, running, could serve as either a reinforcer or a punisher depending on specific circumstances. Other experiments have shown that electrical stimulation of the brain will maintain behavior when it is response-produced, but that the same rats will terminate identical levels of stimulation presented independently of responding (Steiner, Beer and Shaffer, 1969). Similarly, the consequent administration of amphetamine can either increase or decrease subsequent behavior (e.g., Cappell and LeBlanc, 19[illegible] Further experiments have shown that morphine-dependent monkeys w[illegible]rminate an infusion of an antagonist that precipitates withdrawal, [illegible] there are conditions under which responding in the same monkeys [illegible] be maintained when it produces such infusions (Goldberg et al., 1971). These studies have shown that events are not imbued with a singular exclusive behavioral status that is determined independently of other factors. Stimuli have multiple behavioral effects; the behavioral processes of reinforcement and punishment transcend particular events. Under appropriate conditions different events can function similarly and under still other circumstances, the same event may have opposite effects. A complete understanding of the operant processes of reinforcement and punishment requires an experimental focus on factors other than the events themselves.

Schedule-Controlled Behavior

As described previously, behavior emerges from and is differentiated by its environmental consequences. The specific relation between behavior and its consequences is called the schedule. The use of schedule-controlled behavior plays a large role in the research described in subsequent sections. This is due partly to the fact that schedules produce and maintain tremendously orderly and reproducible patterns of behavior. It is significant for this research program that schedules can also determine the specific effects an event will have on behavior. When dealing with the consequences of behavior, it is essential to consider how, when, and under what conditions those consequences are presented (Morse, 1966). Schedules provide an experimental means for creating a diversity of behaviors that have quantitative properties, and which can be precisely manipulated. The concept of schedule-controlled behavior includes the view that ongoing behavior is modulated and maintained through continuing dynamic interactions with the environment. Indeed, as will be shown by the results of experiments conducted during the past year, the fundamental processes of reinforcement and punishment cannot be separated from the schedules involved.

Control of Behavior by the Scheduled Presentation of Noxious Stimuli

The experiments summarized below have concentrated on behavior controlled by electric shock presentation. The variety of ways in which shock can be scheduled, its strikingly different effects on behavior, and the ease with which it can be delivered and manipulated offer unique advantages for systematic research. Although a great deal is known about the control of behavior by noxious stimuli under relatively isolated conditions, little information is available on procedures where behavior is under the control of multiple noxious influences.

In experiments directly related to work summarized in this Progress Report, response-produced electric shock has been shown to either maintain or suppress behavior, or do both, depending on details of the circumstances accompanying its presentation (Kelleher and Morse, 1968; McKearney, 1972; Barrett and Glowa, 1977). As mentioned above, environmental events can produce a number of different behavioral effects that are not attributable to any specific property those events possess. Food, water, access to certain drugs and sex are not reinforcers for all individuals under all conditions. Those circumstances under which these events affect behavior differently, or in multiple ways, reveal much information about the environmental control of behavior.

Figure 1 (page 8), taken from the original proposal, nicely illustrates the many different effects that the presentation of response-produced electric shock can have and also shows how radically different events can engender essentially similar performances. Panel A in this figure depicts typical patterns of responding maintained under a 5-minute fixed-interval schedule of food presentation; responding follows an initial period where no responses occur and is positively accelerated until food is delivered at the end of the 5-minute period. Panel C shows virtually identical performances maintained under comparable fixed-interval schedules by both food and shock presentation. The opposite, punishing effects of electric shock are shown in Panels B and D where shock presentation suppressed responding during those periods indicated by the displaced event pen beneath each record. However, responding under alternate component conditions differed for these two monkeys. In Panel B, responding was maintained by food presentation, whereas in Panel D, shock presentation was the maintaining event. Although the suppression of responding by shock is not unusual, conditions under which shock delivery both maintains and suppresses responding, as in Panel D, serve to illustrate the point that the same event can exert both reinforcing and punishing effects on behavior. As will be specified in subsequent sections, the specific manner in which an event will affect behavior depends on the prior behavioral history, on the schedule under which the event is presented, and on the total features of the more immediate situation in which ongoing behavior takes place. Research conducted during the current contract year has focused on each of these in an effort to arrive at a more complete understanding of the multiple effects of noxious stimuli on behavior.

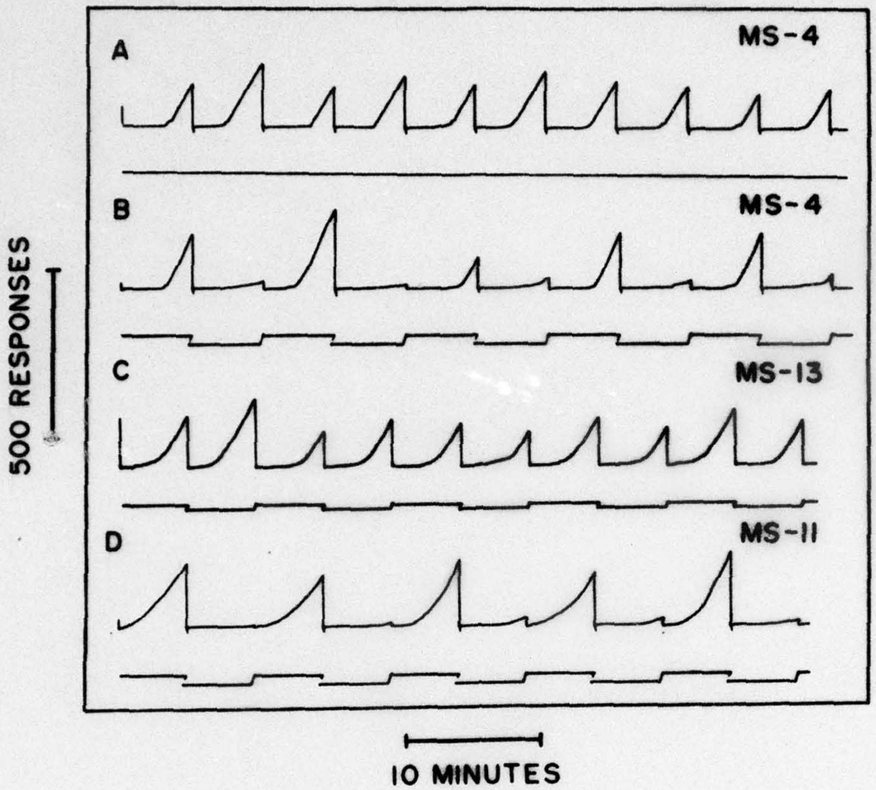

FIGURE 1

Cumulative response records summarizing performances under various schedules of food and shock presentation. These records of lever pressing by squirrel monkeys demonstrate the multiple effects shock can have on behavior. Ordinate: cumulative responses; abscissa: time. In all records the pen reset to baseline at the end of each scheduled condition. Panel A: responding maintained under a 5-min fixed interval schedule of food presentation; i.e., the first response after 5-min elapsed delivered food. Panel B: each 30th response during alternate components produced a 5 mA shock which suppressed responding (punishment). Periods of punished and unpunished responding during the session were indicated by different stimuli. In the records shown above, those portions of the session where responding was punished are indicated by the displacement of the event pen. Panel C: responding maintained under a multiple schedule where either food or shock was delivered after 5-min elapsed. Different stimuli were correlated with food or shock presentation. Note that the patterns and rates of responding were comparable regardless of whether food or shock presentation maintained responding. Panel D: responding maintained <u>and</u> suppressed by shock presentation. During one portion of the session (event pen up), the first response after a 5-min period produced a 9 mA shock; this event maintained high response rates. During the second segment of this session, the first response after a 5-min period produced food but also, during this stimulus, each 30th response produced a 9 mA shock that suppressed responding. Thus, the same shock stimulus was serving as a reinforcer or a punisher, depending on the stimuli present and on the schedule in effect at that time.

General Experimental Methods

Mature healthy squirrel monkeys (Saimiri sciurea) were used in all experiments. The monkeys were maintained in individual cages under well-regulated temperature and humidity conditions.

Experiments were conducted in a specially-constructed primate-restraint chair equipped with response devices, and means for delivery of food and electric shock. Three pairs of colored lamps could be used as discriminative stimuli. Throughout daily experimental sessions, these monkeys were lightly restrained at the waist. The shaved tail was held motionless by a small stock. Two brass electrodes rested on the tail which was coated with EKG sol electrode paste before each daily session. Shock was taken from a 650 v AC source and was delivered through series resistance for 200 milliseconds. Sessions were conducted in accoustically-isolated chambers equipped with white noise to mask extraneous sounds. Data were collected on counters, elapsed time meters and on cumulative response recorders. Relay programming equipment was used to schedule events and collect data.

In most experiments using response-produced shock as the maintaining event, monkeys were typically given preliminary training under shock-postponement (avoidance) schedules. Following this training they were usually placed directly on the appropriate schedule of response-produced shock which then maintained responding. In selected cases, the schedule of shock postponement and shock presentation were in effect simultaneously for a brief period before the postponement schedule was removed. Exposure to the shock postponement schedule for a brief 2-3 week period was typically sufficient for the subsequent maintenance of responding by shock presentation.

Behavioral Interactions Under Multiple Schedules

Experiments conducted in this section have concentrated on an analysis of the nature and extent of potential interactions occurring under procedures where the behaviors of interest are maintained under different stimulus conditions and at different times (multiple schedules). In all of the experiments conducted thus far, behavioral performances have been established under a range of conditions and then, when these performances have stabilized, the behavioral consequences in one condition are modified. The data of fundamental interest have consisted primarily of behavioral changes in those conditions where the consequences have not been altered.

Interactions between behaviors under the control of different environmental stimuli were reported some years ago by Reynolds (1961a, b). In these studies using pigeons, responding was maintained initially under multiple variable-interval schedules that arranged for food to be delivered on the average of every 3 minutes, given that a response occurred. When responding no longer produced food during one of the stimulus components (extinction), responding declined under that condition but increased substantially in the unchanged component (contrast). This outcome was particularly significant for it indicated that even though the behavioral consequences in one context are not modified, changes in that behavior can occur as a result of events occurring elsewhere. Behavioral interactions of this type have been studied extensively using food as the maintaining event and have recently received considerable experimental and theoretical attention (e.g., Rachlin, 1973; Schwartz and Gamzu, 1977).

Experiments conducted during this contract period have focused on the development of performances maintained by the scheduled presentation of shock where shock is maintaining responding by its presentation or termination, or is instead, suppressing responding. These different behavioral effects of shock delivery are intended to provide a range of conditions under which behavioral interactions can be examined. The results of each experiment and its current status will be discussed separately.

Behavioral contrast

In this experiment, after preliminary training under a shock-postponement schedule, responding was established under multiple variable-interval 3-minute schedules of electric shock (8 mA) presentation. The two 3-minute components alternated regularly every 3 minutes and, during each, a response produced shock on the average of every 3 minutes. Red stimulus lamps were illuminated in one component, whereas white stimuli were present throughout the second. The experimental plan was to allow responding to stabilize at comparable rates in each component and then change to extinction in one component. With the exception of the consequent event, this procedure is similar to that studied by Reynolds (1961a, b).

Responding under the multiple variable-interval shock-presentation schedule occurred at a steady rate, characteristic of that maintained by food. Figure 2 (page 11) shows performances of one monkey (MS-32) under the multiple schedule when shock occurred in each component and later when shock was removed during one component (extinction). Response rates were fairly comparable in both components under the multiple schedule when shock occurred in each stimulus condition. When shock was removed from one component, responding declined during that condition but increased markedly under the alternate condition where the shock schedule remained in effect (contrast). These results were also obtained with a second monkey (MS-12), but only after certain conditions.

Although contrast can be obtained using shock presentation as the maintaining event, there are several aspects of this finding that warrants qualification and further study. Figure 3 (page 12) provides a more complete summary of the data obtained thus far in this experiment and suggests that the sequence of experimental manipulations described above can result in both an elevation as well as a decrease in shock-maintained responding when extinction occurs in a different component. The top panel shows changes in performance with MS-12, a monkey added later to this study when MS-36 died. Changing to extinction in one component (labeled B in the figure) with MS-12 resulted in a decrease in responding during both components (induction). The schedule was then changed back to the 3-minute variable-interval schedule for 3 sessions (C) and then the variable-interval schedule was changed to a 1-minute value (D). When shock was again removed, response rates decreased substantially in that component, but were not affected in the unchanged condition (E). These results are difficult to assess because of the short period of time at the

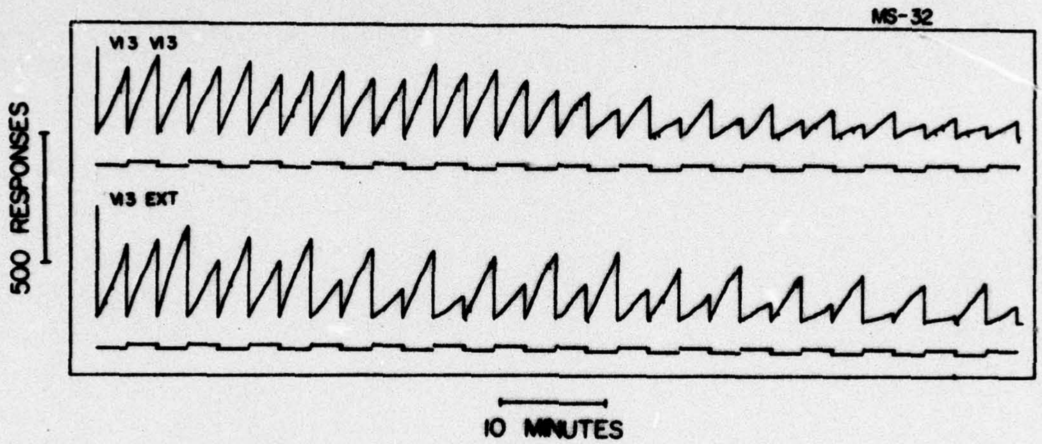

FIGURE 2

Cumulative records showing performance under the multiple variable-interval shock-presentation schedule and under the multiple variable-interval extinction schedule.

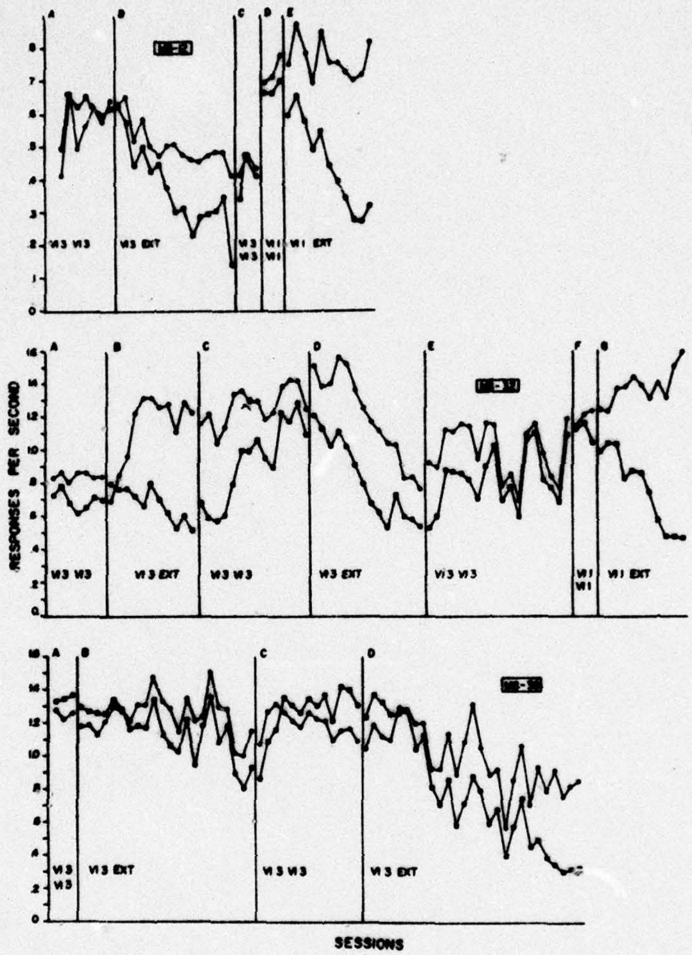

FIGURE 3

Changes in response rates under the multiple variable-interval schedules of response-produced shock and extinction. Filled circles represent response rates during the unchanged (VI) condition, filled squares responding during extinction. See text for description of results.

1-minute value. Further work with this subject is continuing, consisting of a return to the 1-minute schedule in both components to provide a better evaluation of performance under this condition.

The results from a second subject (MS-32), are shown in the second panel of Figure 3. Marked contrast was obtained initially with this subject when extinction was introduced (B) but the elevated rates of responding did not return to their former level when shock was again placed in effect (C). The second exposure to the extinction schedule resulted in decreased response rates in both components (D). Responding was somewhat unstable when returned to the multiple schedule with shock in both components (E) and following brief exposure to a 1-minute shock-presentation schedule in both components (F), contrast was again obtained with extinction in the alternate condition (G).

Finally, the third panel in Figure 3 shows results obtained with MS-36 prior to his death. The initial change to extinction (B) resulted in a slight decrease in rates of responding during both components of the multiple schedule. After a period of reexposure to the multiple schedule with shock arranged in both components (C), introduction of the extinction schedule produced even greater decreases in responding during both components (D).

These results show that although increases in shock-maintained responding can occur in a condition where behavioral consequences do not change, and that these are related to modifications occurring elsewhere, this is far from a reliable finding. Both contrast and induction can occur and, at present, there is no basis for predicting which of these outcomes will prevail. Further work will investigate the role of the parameter value of the variable-interval schedule (shock frequency) and shock intensity as possible determinants of these diverse effects. A consistent and reliable finding demonstrating behavioral contrast under conditions where shock presentation maintains responding would extend the similarities of shock and food as consequent events to another sphere and could be integrated into the theoretical literature on the determinants of behavioral contrast. Accounts of behavioral contrast with food which rely exclusively on the aversive aspects of changing to extinction in one component (i.e., removing food) could not easily account for contrast induced by the removal of shock, which results in a relative decrease in the frequency of noxious stimulation.

<u>Escape responding and punished responding</u>

These experiments are directed at potential interactions occurring between punished behavior and behavior maintained under schedules where responding terminates a visual stimulus correlated with shock (stimulus-shock termination schedules, sometimes called escape responding, Morse and Kelleher, 1966). Under the fixed-interval termination schedules used in these studies, shocks are scheduled to occur <u>t</u> seconds after the end of the fixed-interval; shocks continue to recur with a certain value between them, equal also to <u>t</u>, until a response is made which terminates both shock and the prevailing stimulus conditions, and produces a 1-minute timeout. During timeout, no shocks occur and responding has no scheduled consequences. Fixed-interval stimulus-shock termination schedules can generate and maintain performances remarkably comparable to those maintained by food and shock presentation (see Figure 4, page 14).

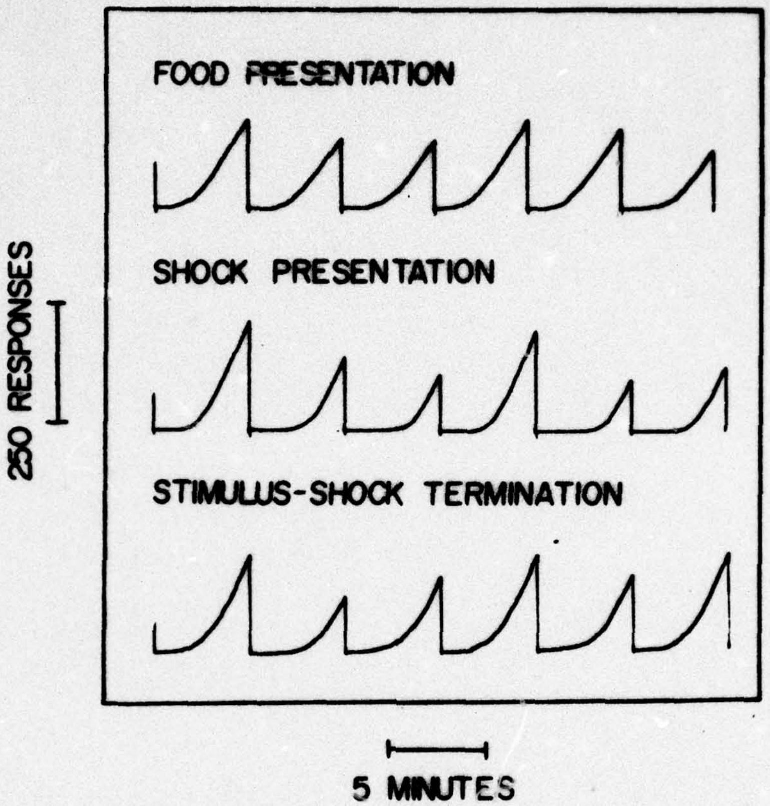

FIGURE 4

Cumulative records showing similar patterns of responding in squirrel monkeys maintained by different events under 5-minute fixed-interval schedules. In the top record the first response after 5-minutes produced a 300 mg food pellet. In the middle record the first response after a 5-minute period produced an 8 mA electric shock. The bottom record shows the effects of a condition where shocks were scheduled to occur 3.0 seconds after the 5-minute fixed-interval elapsed; the first response after the 5-minute interval terminated the prevailing stimuli and prevented further shocks. Each component of all schedules was separated by a 1-minute period where responding had no consequences (timeout). The pens reset to baseline at the end of the timeout period.

In different experiments schedules of stimulus-shock termination have been combined in a multiple schedule alternating with either food presentation or with a second schedule of stimulus-shock termination. The objective in one of these studies was to punish food-maintained responding and then vary features of the termination schedule, in the alternate component, to assess the effects on punished responding. Subsequently, aspects of the punishment schedule could then also be manipulated in an effort to determine whether interactions existed between these differently-controlled behaviors. A similar focus existed in the second experiment, where responding was maintained by multiple stimulus-shock termination schedules. In this case, however, the plan was to punish termination responding in one component and then vary parameters of the schedule in each component, concentrating primarily on ensuing interactions between these behaviors.

These experiments are in various stages at the writing of this report and require further work for their proper completion. Despite the incomplete nature of the findings, there are a number of intriguing details of each which deserve to be pointed out. The progress of each will be summarized separately.

In one study, responding was maintained under multiple 5-minute fixed-interval schedules of either food presentation or termination of the stimulus-shock complex. By manipulating t value and shock intensity it was possible to adjust termination rates to equal those maintained by food. When rates in both components were comparable, a fixed-ratio 30-response schedule of shock presentation was added to the component in which food was delivered. Figure 5 (page 16) shows performance under the multiple schedule without the fixed-ratio schedule of shock delivery and then, later, after the shock-presentation schedule was added. Under the first condition response rates and patterns were comparable, whether maintained by food or by the termination of the stimulus-shock schedule. Superimposing the fixed-ratio schedule on food-maintained responding produced a dramatic increase in rates of responding under this component; termination response rates did not change substantially. Over the next four-month period several changes in the schedule were made in an effort to reduce rates of food maintained responding that also produced fixed-ratio shock. These consisted of variations in shock intensity and frequency, changes in t value, and removal of the termination component, none of which resulted in sustained decreases in food-maintained responding that were consistently less than those maintained under the alternate termination schedule or under the food-presentation schedule alone, prior to the introduction of the fixed-ratio shock. Similar effects were also obtained with a second monkey.

These results are somewhat striking, especially when compared to those obtained when multiple termination schedules are used (see below). Sustained increases in food-maintained responding under a fixed-ratio shock presentation schedule are atypical; the initial increases in responding seem to reflect the prior history of exposure to the termination schedule, but in other studies where shock presentation or food maintains responding in an alternate component, these elevated rates usually decrease. An account of the fact that they have not decreased here remains curiously unavailable at the present time. Two additional monkeys are being trained under comparable conditions in an effort to further document this effect.

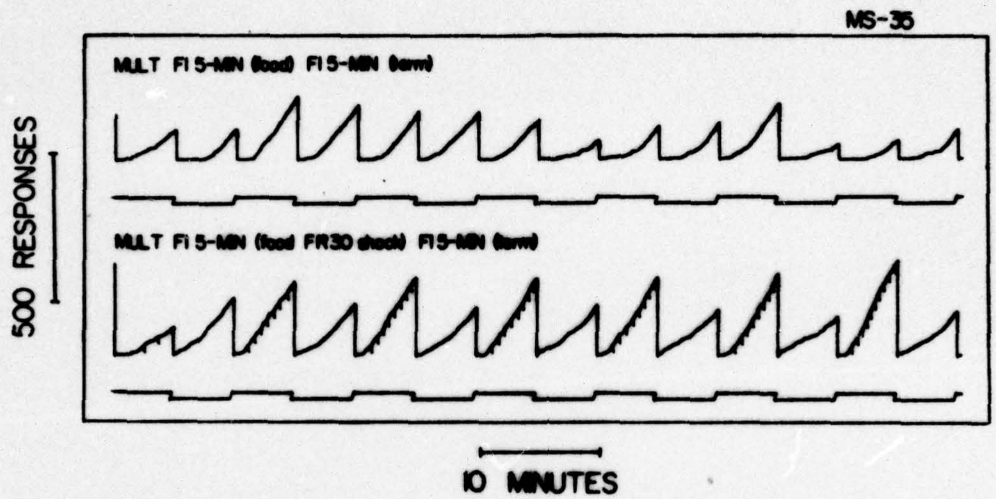

FIGURE 5

Cumulative records of responding under multiple 5-minute fixed-interval schedules where food and termination of a stimulus associated with shock maintained responding. When the event pen was displaced, 8 mA shocks began to occur 2 seconds after the 5-minute interval elapsed and continued to occur until a response was made that terminated shock and the prevailing stimuli. A one-minute timeout separated each component. In the lower record a 30-response shock (8 mA) presentation schedule was in effect along with that of food. Note the pronounced and sustained increases in food-maintained responding under this condition. The recording pen reset after timeout.

The second experiment in this series has concentrated on analyzing interactions between behavioral consequences under multiple fixed-interval termination schedules where responding in one component is punished. In this study a 30-response fixed-ratio shock-presentation schedule was added to a component under which a response terminated shock and related stimuli after 5 minutes elapsed. An identical condition, but without the fixed-ratio schedule, existed in the alternate component. As in the experiment just described, the initial introduction of shock increased response rates in that component; in this study increases also occurred in responding during the alternate condition. Within 7 days, however, responding declined systematically during the component associated with the fixed-ratio schedule. Because response rates declined below those existing prior to the introduction of the fixed-ratio shock, it is appropriate to speak of punished responding.

Figure 6 (page 18) shows these initial effects and also shows the effects of variations in the value of $\underline{t}$ in the component where responding was not punished. Over the course of about four months, $\underline{t}$ was varied from 0 seconds (inevitable shock) to 3 seconds, only in the nonpunishment component. The value of $\underline{t}$ remained unchanged in the punishment component. Although often large changes occurred in rates of unpunished termination responding, these changes did not affect punished responding occurring in the alternate component. A second monkey required a lower fixed-ratio value (10 responses) to obtain reliable and consistent suppression. The results of changes in $\underline{t}$ during the alternate component did not affect punished responding with this monkey either, thereby confirming results obtained with the first subject. The next series of manipulations in this experiment will involve changes in features of the schedule controlling punished responding to see if an interaction exists in an opposite direction from that we have focused on in the past year. This will involve holding the parameters controlling unpunished responding constant and varying punishment frequency and $\underline{t}$ value in that component.

Figure 7 (page 19) shows cumulative records from three phases of this study, illustrating performance under the multiple termination schedule (Panel A), the initial effects of introducing shock during one component (Panel B) and stable performances of punished and unpunished responding (Panel C). These performances are striking because the same stimulus (electric shock) is controlling behavior differently, depending simply on the schedule under which it occurs. The effects of punishing responding maintained by shock termination has not been studied extensively. The schedule being used in these experiments is somewhat unique in that the same event that maintains responding by its termination also suppresses responding when it is presented. If the suppression is too great, the frequency of termination shocks will increase which will then increase response rates. However, if the increases in termination responding are too large, this will result in increases in the number of shocks delivered under the punishment schedule. This example is one further instance where the schedule generates a dynamic balance between responding and its consequences that results in a stable equilibrium. Studies of the type proposed here promise to reveal useful information on punished behavior, escape behavior and interactions between these prevalent forms of behavioral control.

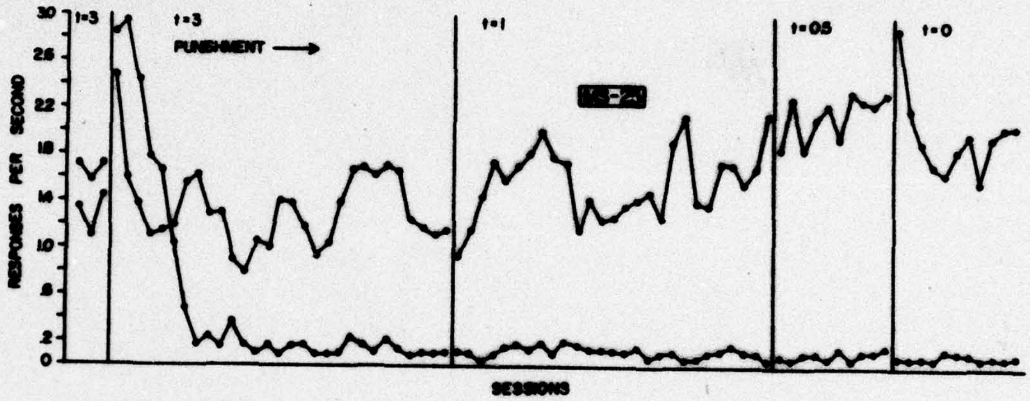

FIGURE 6

Effects of adding fixed-ratio shock under a multiple fixed-interval 5-minute stimulus-shock termination schedule. Second panel indicates the beginning of the added fixed-ratio 30-response shock-presentation schedule to one component. Subsequent panels show changes in t value in the non-punishment component.

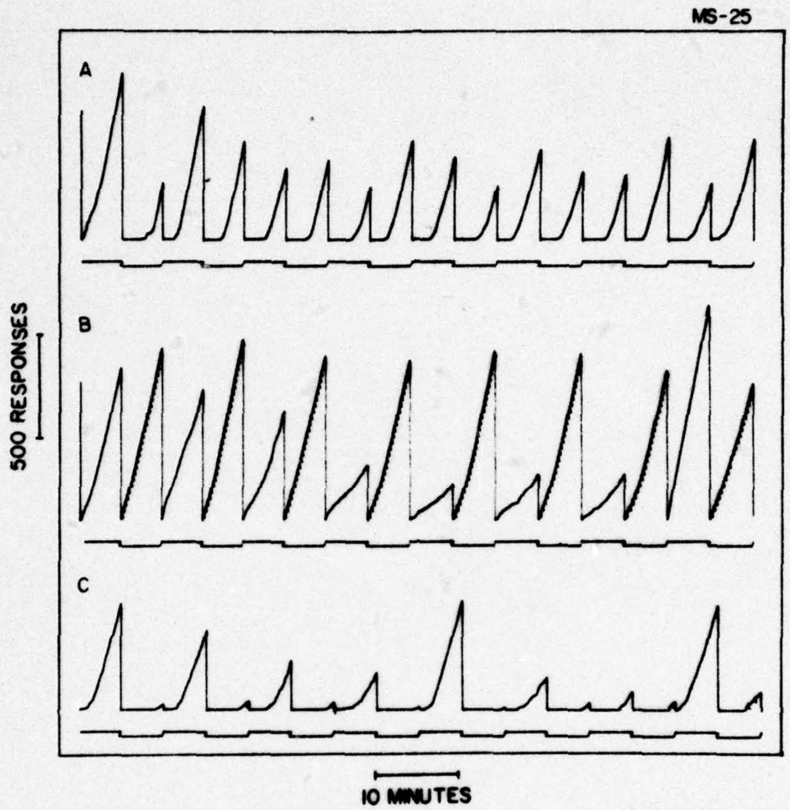

FIGURE 7

Cumulative records of performances maintained under a multiple 5-minute fixed-interval schedule of stimulus-shock termination (Panel A). In the middle record (Panel B) each 30th response during one component produced shock which increased rates dramatically (taken from the second session). The lower record (Panel C) shows performances after about 20 sessions under the schedule where termination responding was punished in one component.

Reinforcement and punishment of behavior by the same event

As mentioned previously, the processes of reinforcement and punishment refer to reproducible relations between a behavior and its consequences under particular environmental conditions. When the consequences of a particular behavior result in the subsequent increase and temporal modulation of that behavior, reinforcement is said to have occurred and that consequent event is called a reinforcer. Conversely, if a response-produced event decreases subsequent responding, the process of punishment is implicated and the event is identified as a punisher. Depending on specific circumstances, then, a normally punishing event can have either reinforcing or punishing properties.

In the present experiment shock presentation both maintained and suppressed responding. The punishing shock was scheduled intermittently and was presented during a condition where responding was also maintained by food. During different stimulus conditions responding was developed initially under a shock-postponement schedule and was maintained ultimately by the presentation of shock.

Both monkeys initially responded under a two-component multiple schedule. In the presence of white light each depression of the response lever postponed shock for 25 seconds; otherwise shocks occurred every 5 seconds until a response was made. In the second component of this initial condition, correlated with a pair of yellow lights, the first response occurring after 5 minutes produced access to 0.3 cc of SKF liquid squirrel monkey diet (5-minute fixed-interval schedule of food presentation). The two schedule components were alternately present for 5-minute periods and were separated by a 1-minute timeout during which the chamber was dark and responding had no scheduled consequences.

When responding stabilized, a second condition was introduced during the food cycle of the schedule. In this phase, the first response after 5 minutes still produced food but, in addition, each 30th response during that interval also produced an electric shock.

In the next phase a fixed-interval 5-minute schedule of shock presentation was placed in effect simultaneously with the shock-postponement schedule. During this condition, each response continued to postpone shock, but the first response after 5 minutes also produced a shock of the same intensity. Finally the avoidance schedule was removed and responding was maintained under the fixed-interval shock-presentation schedule alone. Table 1 (page 21) summarizes the sequence of experimental conditions and the number of sessions for each monkey at each condition.

Figure 8 (page 22) shows performances under all schedule conditions. Under the shock-postponement schedule responding occurred at a fairly steady rate throughout the 5-minute cycle; few shocks occurred after responding developed. Under the fixed-interval food-presentation schedule responding followed an initial pause and was positively accelerated throughout the remainder of the interval.

Table 1

MEAN RESPONSE RATES (RESPONSES PER SECOND) UNDER VARIOUS EXPERIMENTAL PROCEDURES

Component 1		Component 2		No. Sessions	
		Monkey MS-4			
Shock postponement	(.738)	FI food	(.430)	16	(A)
Shock postponement	(.662)	FI food + FR shock	(.217)	26	(B)
FI shock	(.395)	FI food + FR shock	(.201)	18	(C)
		Monkey MS-11			
Shock postponement	(.128)	FI food	(.260)	18	(A)
Shock postponement	(.107)	FI food + FR shock	(.087)	25	(B)
FI shock	(.572)	FI food + FR shock	(.035)	21	(C)

Note - Figures in parentheses represent the mean response rates of the last four sessions under each of the different schedule conditions. Letters in parentheses refer to performances from those conditions shown in Figure 8.

Figure 8B and Table 1 show that food-reinforced responding was decreased substantially when every 30th response produced shock; the introduction of shock during the food presentation had little effect on responding under the shock-postponement schedule. Thus during this condition responding was maintained by shock postponement (avoidance) and was suppressed by shock presentation (punishment).

In the final phase of this experiment responding was maintained with both monkeys under the fixed-interval shock-presentation schedule alone when the avoidance schedule was removed. Patterns and rates of responding under this final phase are shown in Figure 8C and in Table 1 respectively. Under the fixed-interval shock-presentation schedule responding was characteristic of that maintained by food; there was an initial period of no responding followed by a gradual acceleration to a high terminal response rate (see also Figure 8A). Although the presentation of shock maintained responding under the fixed-interval schedule, presentation of the same shock continued only to suppress responding maintained by food in the alternate component.

In subsequent manipulations, when the shock that was scheduled to occur under the fixed-interval schedule was removed (extinction), responding during that component decreased to a low level. Conversely, removal of the shock delivered after each 30th response during the food presentation component resulted in an increase in responding to its former nonpunished level. When

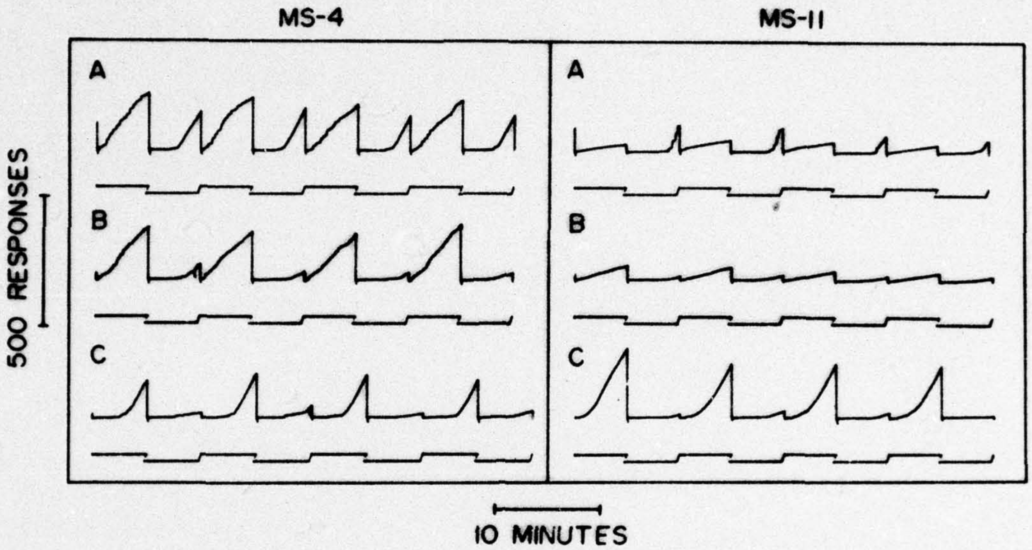

FIGURE 8

Cumulative response records depicting performance of both monkeys during the various experimental conditions. The response pen reset to the baseline at the end of each component. The event line beneath each record was displaced during that portion of the session when the 5-minute fixed-interval schedule of food presentation was in effect and when every 30th response during this component also produced shock. The event pen was up during the shock-postponement (avoidance) and fixed-interval 5-minute shock presentation schedules. Shocks delivered during the food presentation component are indicated by a diagonal slash on the record. (A): Multiple shock postponement (avoidance) and fixed-interval 5-minute food-presentation schedule; (B): same as A except that every 30th response during the fixed-interval 5-minute food schedule also produced shock. Food-maintained responding was suppressed by shock during this component (punishment). (C): Fixed-interval 5-minute schedule of shock presentation alternating with the 5-minute fixed-interval food-presentation schedule where each 30th response also produced shock. This panel shows the maintenance and suppression of responding by shock presentation, demonstrating that the same stimulus can exert both reinforcing and punishing effects on behavior.

shock was reintroduced in later sessions, responding was again increased under the fixed-interval schedule and was decreased by the 30-response shock schedule.

Changes in the rate and temporal pattern of responding engendered and maintained by the fixed-interval schedule of shock presentation in this experiment exemplify the behavioral process of reinforcement: responding was modified and maintained by its consequences, assuming characteristic patterns consistent with the schedule under which shock was delivered. Yet, when the same electric shock was scheduled differently, shock presentation reduced food-maintained responding and functioned as a punisher.

The demonstration of both reinforcing and punishing effects of shock presentation in the same organism at the same time questions the utility of classifying events independently of how these events affect behavior. The effects of salient environmental events are varied; which of the effects a given event will have is complexly determined and not an exclusive property of the event itself. It is simply wrong to define categorically an event as either a reinforcer or as a punisher without specifying the conditions under which these effects are observed (cf., Morse and Kelleher, 1970; 1977). This point will be discussed again in the concluding section of this report.

Behavioral Interactions Under Concurrent Schedules

In addition to concentrating on interactions between behaviors occurring sequentially under different environmental contexts, our research efforts have also analyzed several features of behavior under the control of concurrent schedules. A concurrent schedule arranges for at least two schedules to be simultaneously and independently in effect. Although concurrent schedules have involved a number of different procedures (e.g., see Catania, 1966; de Villiers, 1977), in experiments conducted under this proposal, we have generally used conditions where two different schedules are in effect simultaneously, each schedule is associated with a separate manipulandum or response device. The basic interest in pursuing those studies detailed below has been that of first determining the feasibility of attempting to develop concurrent performances controlled by noxious stimuli and, secondly, to analyze the nature and extent of the interactions between these behaviors. Progress during the first year has been substantial in both these areas with the outcomes generally exceeding the original objectives and anticipated results.

Simultaneous maintenance of behavior by shock presentation and termination

In one experiment two separate responses were developed and then maintained simultaneously both by a shock-presentation schedule and by termination of that shock schedule and associated visual stimuli. Initially performances were developed on a single lever using a 3-minute variable-interval shock-presentation schedule. After approximately 25 sessions, a second lever was introduced to the left of the existing lever. Responding on the right lever continued to produce shock under the variable-interval schedule. Concurrently, however, the first response on the left lever after 3 minutes (3-minute fixed-interval schedule) terminated the schedule of electric shock presentation associated with the right lever and initiated a 1-minute timeout period. During the timeout, the white stimulus lamps that normally illuminated the chamber were extinguished and responding on either lever had no scheduled consequences. At the end of the timeout, the white stimulus lamps again illuminated the chamber and the schedule conditions correlated with each lever were again in effect. Sessions ended after the twentieth timeout (about 80 minutes).

After 112 sessions, the schedules associated with each lever were reversed: responding on the left lever now produced electric shocks under the variable-interval schedule and responding on the right lever terminated the shock-presentation schedule and the stimuli associated with shock under the fixed-interval schedule. After 47 sessions, the schedules associated with each lever were returned to the original condition for 50 additional sessions.

The intensity of electric shock was then varied between 0 and 10 mA. Each shock intensity remained in effect for a minimum of 15 sessions and until no systematic trends in responding were observed for at least five consecutive sessions. The order of shock intensities studied was: 7, 5, 7, 10, 7, 1, 7, 3, 0 and 7 mA.

Under the two-lever concurrent schedule, stable rates and patterns of responding on each lever were appropriate to the contingencies and schedules prevailing for responding on that lever (Figure 9, page 25). Responding on the right lever, where responses produced electric shocks under the variable-interval schedule, occurred at a moderately high and fairly constant rate, characteristic of that maintained under variable-interval schedules of food or shock presentation. Patterns of responding on the left lever, where the first response after 3 minutes terminated the shock schedule and the stimuli associated with shock, resembled those usually found under fixed-interval schedules of food presentation, electric shock presentation or stimulus-shock complex termination; responding followed an initial pause and was positively accelerated as the interval progressed. The delivery of response-produced shock following a response on the right lever did not appear to either initiate or disrupt responding on the left lever (see Figure 9).

Figure 10 (page 26) shows the development of responding under the two-lever concurrent schedule for each monkey. Responding on the right lever, where responses produced shocks under the variable-interval schedule, was relatively unaffected when the second lever was introduced (compare Panels A and B, Figure 10). When the left lever was first introduced (Panel B), the rate of responding on that lever was initially very low for MS-2; throughout the first session, the schedule of shock presentation was often not terminated until well after the 3-minute fixed interval had elapsed. The rate of responding on the left lever was initially much higher for MS-1 but patterning was not differentiated throughout each cycle. By the sixth session (Panel C), the rate of responding on the left lever increased for MS-2 and characteristic fixed-interval patterns of responding began to emerge for both monkeys. By the twelfth session (Panel D), responding on the left lever was typical of that maintained for the next 100 sessions (see Figure 9).

When the schedule conditions associated with each lever were reversed,

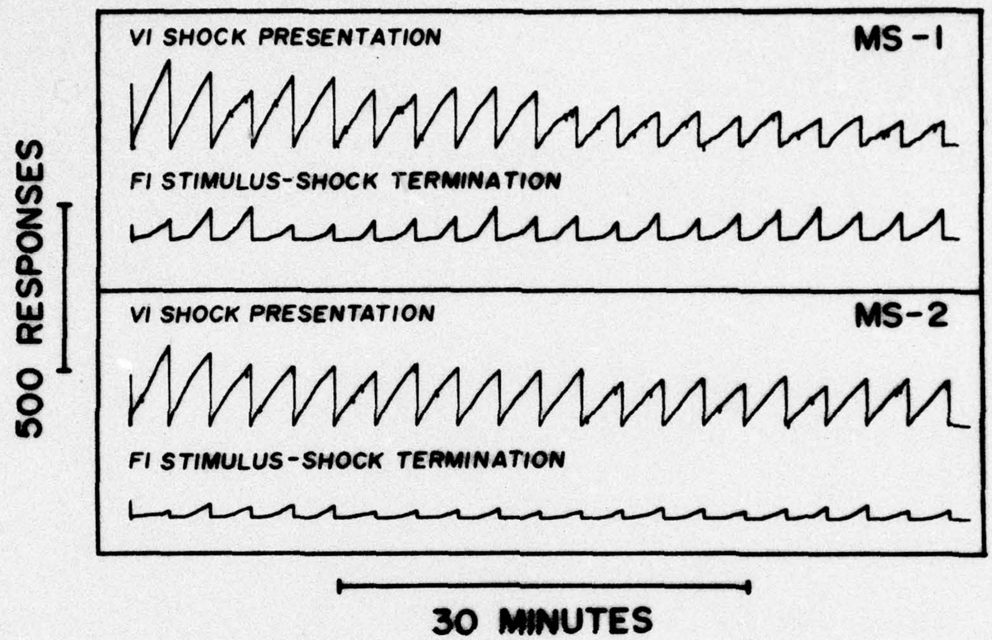

FIGURE 9

Cumulative records showing schedule-appropriate rates and patterns of responding after 95 sessions under the two-lever concurrent schedule for each monkey. Presses on the right lever produced a 7 mA electric shock on the average of every 3 minutes (upper record in each panel). A press on the left lever after 3 minutes terminated the schedule of shock presentation and extinguished the white lights in the chamber for a one-minute timeout period (lower record in each panel). During timeout responding had no scheduled consequences and the recorder motor was not operated. Shock presentations are indicated by diagonal marks. The pens were reset at the end of each timeout period.

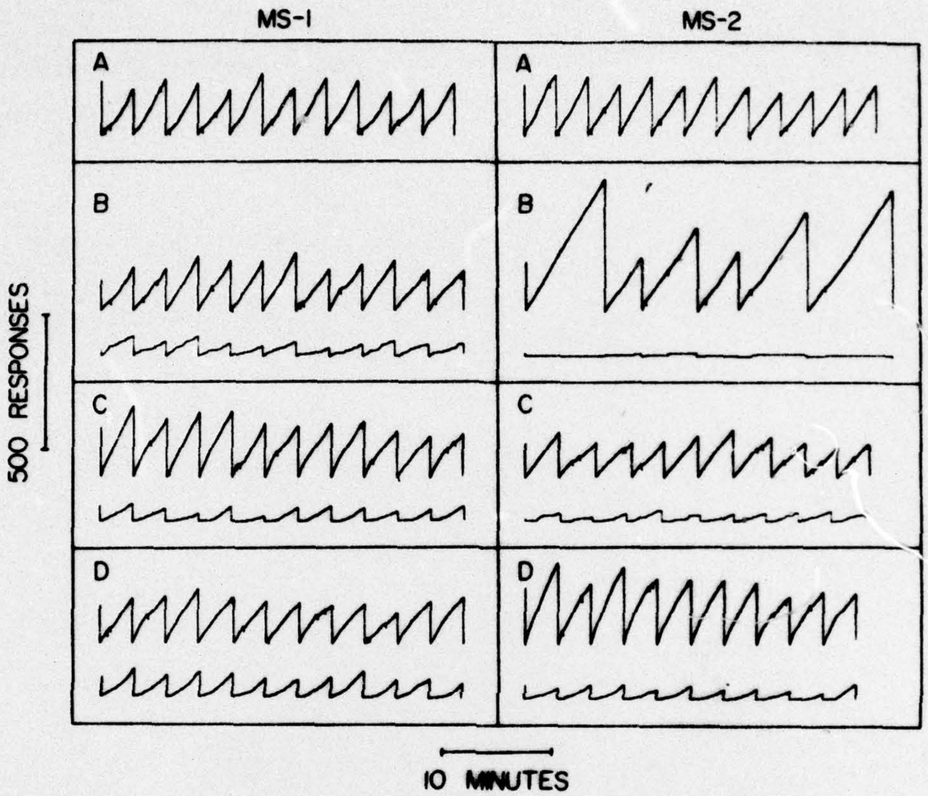

FIGURE 10

Portions of cumulative records showing stable responding under the single lever variable-interval schedule of shock presentation (Panel A) and the development of responding under the two-lever concurrent schedule for each monkey. Sessions 1, 6 and 12 under the concurrent schedule are shown in Panels B-D respectively.

rates and patterns of responding changed accordingly. The rate of responding maintained under the variable-interval schedule of shock presentation was consistently higher than that maintained under the fixed-interval termination schedule regardless of the particular lever associated with each schedule (Table 2). These effects were again reversed when the original conditions were reinstated.

Table 2

Mean individual response rates (responses per second) for each monkey (MS-1 and MS-2) on each lever under the three conditions of the experiment. Responding on the right lever initially produced shock under a 3-minute variable-interval (VI) schedule and, on the left lever, terminated shock and the stimuli associated with shock under a 3-minute fixed-interval (FI) schedule. The consequences arranged by schedules on each lever were reversed twice. Data represent the mean of the last 3 sessions under each condition.

		MS-1		MS-2	
Schedule		VI	FI	VI	FI
VI (right)	FI (left)	.965	.449	.853	.105
VI (left)	FI (right)	1.295	.511	.935	.322
VI (right)	FI (left)	.911	.411	.640	.317

The effects of changes in shock intensity on rates and patterns of responding are shown in Figures 11 (page 28) and 12 (page 29). The rate of responding on each lever was lowest when no shocks were delivered (0 mA). As shock intensity was increased from 0 - 10 mA, responding under the variable-interval schedule of shock presentation increased markedly. Responding under the fixed-interval termination schedule increased when the shock intensity was increased from 0 - 7 mA but decreased slightly at the 10 mA intensity. Increases in responding under the fixed-interval termination schedule were never as great as those under the variable-interval schedule of shock presentation.

Figure 12 shows changes in response patterns at 0, 3, 7 and 10 mA intensities for MS-2. These changes were essentially identical with the other monkey. When no shocks were delivered (0 mA), responding on each lever occurred irregularly and at a reduced rate (Panel A). At successively higher

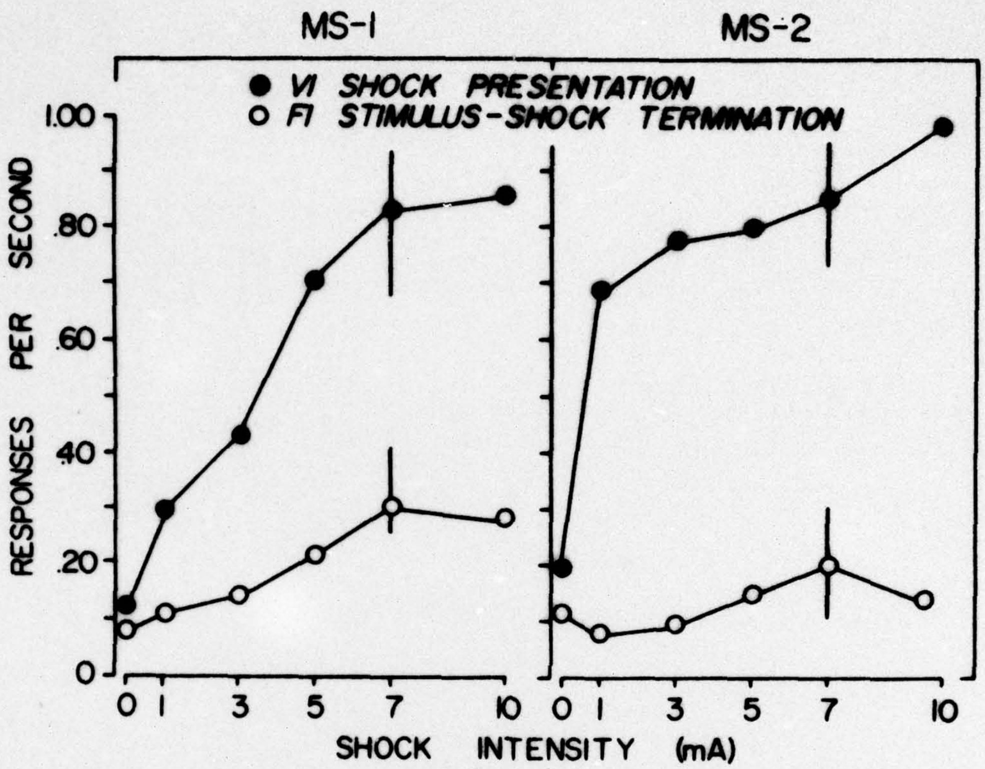

FIGURE 11

Effects of changes in shock intensity on responding under the two-lever concurrent schedule. Points are based on means of the last 3 sessions under each condition. Vertical lines show the range of observations when the 7 mA intensity was redetermined on five separate occasions.

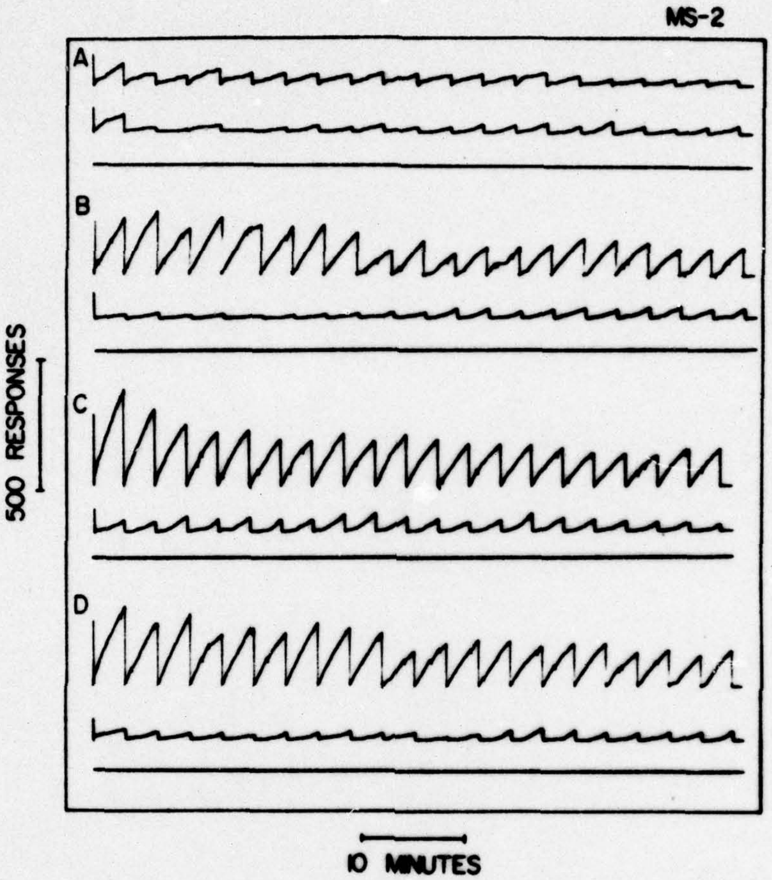

FIGURE 12

Cumulative records showing changes in rates and patterns of responding at 0, 3, 7 and 10 mA shock intensities (Panels A-D, respectively) for MS-2.

shock intensities, characteristic patterns of responding emerged on each lever (Panels B-D).

In this experiment, as in others (e.g., Byrd, 1969; Kelleher and Morse, 1968; McKearney, 1968; Stretch, Orloff and Dalrymple, 1968) the presentation of electric shock maintained schedule-appropriate patterns of responding. Although response-produced shock maintained responding in the present study, a similar response was also simultaneously maintained by the termination of the shock schedule and of the stimuli associated with it. These concurrent responses were distinguishable in terms of their temporal patterning and in terms of their sensitivity to changes in shock intensity. The results of this study illustrate the dangers of categorical classifications of behaviorally relevant events based on their physical properties. The seemingly paradoxical effects of electric shock observed here emphasize the difficulty in attempting to assign behavioral properties to events independently of the effects those events have on behavior. Environmental events can exert multiple behavioral effects and a classification of those events cannot be based meaningfully on a priori considerations.

Previous experiments in which response-produced presentations of electric shock maintained responding have stressed the critical role of the organism's prior experience, ongoing behavior and the prevailing schedule in developing those performances (Kelleher and Morse, 1968; McKearney, 1968; Morse and Kelleher, 1970; 1977). In the present study responding was first established under a shock-postponement schedule and, somewhat later, was maintained under the variable-interval schedule of shock presentation. Finally, responding was maintained simultaneously by the presentation of shock and by the termination of the shock schedule and of the stimuli associated with it. Although the processes of positive and negative reinforcement have been applied to these respective conditions, these terms all too often have unfortunate connotations that imply inherent qualitative event characteristics. Since behavior is always increased by reinforcement, the additional specification of whether events are presented or terminated (i.e., a description of the schedule) is sufficient and circumvents possible erroneous assumptions about the nature of those events.

It is interesting to note that under certain conditions, responding can also be maintained when it terminates a visual stimulus associated with food presentation (Azrin, 1961; Thompson, 1964). The similarity of this finding to that reported here stresses the critical role of the environmental context in which behavior occurs as a means of revealing the multiple behavioral effects of environmental events. Although both food and shock presentation can each maintain responding when studied in isolation, the availability of another response discloses the multiple and dynamic effects these events can have on behavior.

Simultaneous maintenance of behavior by food and shock presentation

A second experiment in this series is addressed to the study of interactions under concurrent schedules of food and shock presentation. Progress in this study has been somewhat slow and has been impeded further by the recent death of one of the subjects. Nevertheless, training with a second subject has begun and the experiment will continue into the next year. In brief, initial training was conducted using a single lever on which responses produced food under a variable-interval 3-minute schedule. When rates of responding were stable, that lever was removed and a second one inserted in a different location. After a one-month period of training under a shock-postponement schedule, a 3-minute variable-interval schedule was placed in effect. The next phase will consist of making both food and shock simultaneously available under the concurrent schedule and determining the extent to which manipulations in one of the schedules affects behavior maintained by the other. These results will be especially interesting in view of the conspicuous absence of literature on concurrent behaviors controlled by dissimilar events.

<u>Simultaneous maintenance of behavior by presentation and postponement of shock</u>

This experiment began with the objective of developing performances under concurrent schedules of shock presentation where shock frequency and intensity were to be manipulated. In establishing these performances, however, it seemed appropriate to use different manipulanda and to investigate the contribution of an avoidance history on one manipulandum to the development of shock-maintained responding on the second. The outcome of this initial slight deviation from the primary objective has been extremely beneficial and provocative and has acquired a separate status of its own. Presently, it seems most appropriate to pursue this further, since it bears directly on the overall orientation of the program.

In this study the standard primate chair was equipped with a chain suspended from above, located to the left of the response lever. A shock-postponement schedule was initially in effect and was associated only with the chain; shocks were scheduled to be delivered every 5 seconds unless a response occurred which postponed the next shock for 25 seconds. The lever was present throughout this initial period but responding on it had no consequences. After approximately two months, a 3-minute fixed-interval shock-presentation schedule was placed in effect for responding on the lever. Under this schedule, the first response after 3 minutes produced the same shock that was avoided by chain pulling. Still very few responses occurred on the lever over approximately three weeks. Subsequently, the chain and the associated avoidance schedule were removed, leaving only the lever and fixed-interval shock-presentation schedule.

Responding developed on the lever within two sessions after the chain was removed. Significantly, over the next month or so, patterns of responding characteristic of those maintained under fixed-interval schedules developed. Figure 13 (page 32) shows performances maintained on the lever alone (top panel) by the shock-presentation schedule and, later, under the concurrent schedule when the chain and shock-postponement schedule were reintroduced (lower panel). Under the concurrent schedule, fixed-interval patterns were apparent on the lever, whereas steadier rates of chain pulling were maintained by the avoidance schedule.

In this experiment responding was developed and maintained on the lever

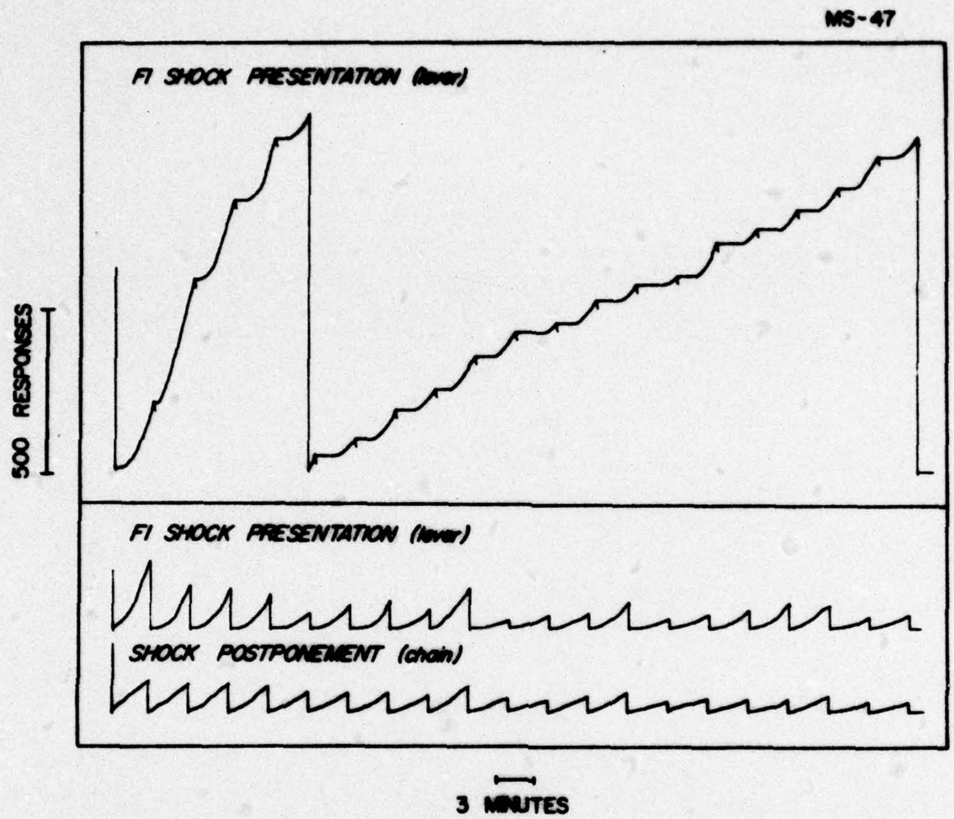

FIGURE 13

Cumulative records depicting performances maintained on a lever where responding produced shock under a 3-minute fixed-interval schedule (top panel). Shocks are indicated by diagonal slashes. The pen reset after 1100 responses. This performance occurred after a history of responding under a shock-postponement schedule where a chain was the response device. The bottom pair of records illustrates early (subsequent) performances of the same monkey under a concurrent shock-postponement fixed-interval 3-minute schedule of response-produced shock. The fixed-interval schedule was arranged for responding on a lever, the shock-postponement schedule on a chain; both schedules were in effect simultaneously. The pens reset after shock was delivered. Note the positively accelerated patterns of responding under the fixed-interval schedule (lever) and the steadier, constant rates of responding under the shock-postponement schedule (chain).

under a shock-presentation schedule without a history of shock postponement on this manipulandum. This outcome suggests that avoidance history is sufficient to develop responding maintained by shock presentation, even when the latter performance is topographically and spatially different from that of the avoidance schedule.

The second aspect of this outcome that warrants attention is that many previous accounts of responding maintained by the presentation of response-produced shock have suggested the importance of the ongoing rate of responding as an important factor in ultimately maintaining responding by shock presentation. In those accounts, shock delivery is seen to modulate pre-existing levels of responding (e.g., Morse and Kelleher, 1970; Morse, Mead and Kelleher, 1967). This would not seem to be the case in the present study where the pre-existing rates of lever pressing were essentially zero. It would appear that performances maintained by response-produced shock can be developed in a variety of ways.

Further research is essential to document interactions under this schedule. At the present time it appears that quite separate behavioral performances can be developed under concurrent schedules of the type used thus far. It remains for subsequent studies to determine the type and extent of interactions occurring under these conditions.

Conclusions

Current behavior is often dramatically affected by prior behavioral consequences, by other ongoing behavior and by conditions existing under different environmental contexts. This research program was initiated to focus on these factors as they act singly or interact together to influence the development, maintenance and modification of behaviors controlled predominately by noxious events. Of particular interest were possible interactions occurring between behaviors separated temporally and under the control of different stimuli (multiple schedules), and those behaviors that can occur simultaneously (concurrent schedules).

Experiments conducted during the past year have analyzed a wide variety of conditions under which different schedules of shock maintained quite different behaviors. Presentation of the same electric shock can function as a reinforcer or as a punisher depending on the conditions preceding and accompanying its delivery; shock presentation can also do both at approximately the same time and with the same organism. Because historical factors and contextual features of an organism's environment can critically influence the effect of events on behavior, it is impossible to attribute singular behavioral properties to any event. This fact in no way delimits the concepts of reinforcement or punishment, since certain factors have always been significant in the development of any stimulus as a reinforcing or punishing event. For example, the efficacy of food as a reinforcer is determined by factors such as the level of deprivation, the organism's prior experience, and the schedule under which it is presented. Food presentation is not a reinforcer under all conditions and its presentation may even suppress behavior under certain circumstances (Azrin and Hake, 1969; Barrett, 1975).

There has been an overriding tendency to focus on the alleged role of noxious events in the genesis of behavioral pathology. Such efforts have emphasized the disruptive and disorganizing effects of aversive events. The results of the experiments conducted during the course of the past year suggest that exceedingly orderly and integrated behaviors can be developed and maintained over extended periods of time solely by electric shock presentation. Even more dramatic evidence for this point comes from those experiments where shock presentation functioned differently depending on the manner in which it was scheduled. It is significant that performances engendered and maintained by shock can be identical to those maintained by dissimilar events such as food, drugs and brain stimulation. Behavior is controlled to a greater extent by the nature of the schedule than by the event that is scheduled.

The behavioral effects of environmental events also depend on the behavioral history of the individual. This result was quite clearly demonstrated in the experiment summarized above where responding on a lever developed and was maintained by response-produced shock. The maintenance of lever pressing under the shock-presentation schedule occurred after prior training under a shock-postponement schedule using a completely different response. Prior experience under an avoidance schedule, even with a completely different response, is sufficient for the prolonged maintenance of responding by electric shock presentation. Similar effects of a previous history influencing current behaviors were seen in those experiments where fixed-ratio schedules of electric shock initially produced substantial increases in responding if monkeys had prior exposure to stimulus-shock termination schedules. Current behavior depends very much on both the prevailing schedule conditions and on previous history. As shown in the present research, these factors can interact to result in unique behavioral effects when noxious environmental events occur.

This research has demonstrated the feasibility of developing a vast range of complex behavioral performances that can be differently and precisely controlled by the same aversive event. The further refinement of these performances, with continued emphasis on details of the individual's past history and current environmental conditions, will permit the intensive study of variables that have yet to receive adequate experimental attention. An understanding of the contribution of these multiple influences, alone and in combination, promises to yield information not only on the control of behavior by noxious events but about basic behavioral processes as well.

References

Azrin, N. H.: Time-out from positive reinforcement. Science, 1961, 133, 382-383.

Azrin, N. H. and Hake, D. F.: Positive conditioned suppression: Conditioned suppression using positive reinforcers as the unconditioned stimuli. Journal of the Experimental Analysis of Behavior, 1969, 12, 167-173.

Barrett, J. E.: The Estes-Skinner procedure: Inadequacy of traditional interpretations. Psychological Record, 1975, 25, 167-172.

Barrett, J. E. and Glowa, J. R.: Reinforcement and punishment of behavior by the same consequent event. Psychological Reports, 1977, 40, 1015-1021.

Byrd, L. D.: Responding in the cat maintained under response-independent electric shock and response-produced electric shock. Journal of the Experimental Analysis of Behavior, 1969, 12, 1-10.

Cappell, H. and LeBlanc, A. E.: Punishment of saccharin drinking by amphetamine in rats and its reversal by chlordiazepoxide. Journal of Comparative and Physiological Psychology, 1973, 85, 97-104.

Catania, A. C.: Concurrent operants. In W. K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts, 1966.

de Villiers, P.: Choice in concurrent schedules and a quantitative formulation of the Law of Effect. In W. K. Honig and J. E. R. Staddon (Eds.), Handbook of operant behavior. Englewood Cliffs: Prentice-Hall, 1977.

Goldberg, S. R., Hoffmeister, F., Schlicting, V. V. and Wuttke, W.: Aversive properties of nalorphine and naloxone in morphine-dependent rhesus monkeys. Journal of Pharmacology and Experimental Therapeutics, 1971, 179, 268-276.

Kelleher, R. T. and Morse, W. H.: Schedules using noxious stimuli: III. Responding maintained with response-produced electric shocks. Journal of the Experimental Analysis of Behavior, 1968, 11, 819-838.

McKearney, J. W.: Maintenance of responding under a fixed-interval schedule of electric shock presentation. Science, 1968, 160, 1249-1251.

McKearney, J. W.: Maintenance and suppression of responding under schedules of electric shock presentation. Journal of the Experimental Analysis of Behavior, 1972, 17, 425-432.

Morse, W. H.: Intermittent reinforcement. In W. K. Honig (Ed.), Operant behavior: Areas of research and application. New York: Appleton-Century-Crofts, 1966.

Morse, W. H. and Kelleher, R. T.: Schedules as fundamental determinants of behavior. In W. N. Schoenfeld (Ed.), The theory of reinforcement schedules. New York: Appleton-Century-Crofts, 1970.

Morse, W. H. and Kelleher, R. T.: Determinants of reinforcement and punishment. In W. K. Honig and J. E. R. Staddon (Eds.), Handbook of operant behavior. Englewood Cliffs: Prentice-Hall, 1977. Pp. 174-200.

Morse, W. H., Mead, R. N. and Kelleher, R. T.: Modulation of elicited behavior by a fixed-interval schedule of electric shock presentation. Science, 1967, 157, 215-217.

Premack, D.: Toward empirical behavior laws, I: Positive reinforcement. Psychological Review, 1959, 46, 219-233.

Premack, D.: Reinforcement theory. In D. Levine (Ed.), Nebraska symposium on motivation. Lincoln: University of Nebraska Press, 1965.

Rachlin, H.: Contrast and matching. Psychological Review, 1973, 80, 217-234.

Reynolds, G. S.: An analysis of interactions in a multiple schedule. Journal of the Experimental Analysis of Behavior, 1961, 4, 107-117. (a)

Reynolds, G. S.: Behavioral contrast. Journal of the Experimental Analysis of Behavior, 1961, 4, 57-71. (b)

Schwartz, B. and Gamzu, E.: Pavlovian control of operant behavior. In W. K. Honig and J. E. R. Staddon (Eds.), Handbook of operant behavior. Englewood Cliffs: Prentice-Hall, 1977.

Steiner, S. S., Beer, B. and Shaffer, M. M.: Escape from self-produced rates of brain stimulation. Science, 1969, 163, 90-91.

Stretch, R., Orloff, E. R. and Dalrymple, S. D.: Maintenance of responding by a fixed-interval schedule of electric shock presentation in the squirrel monkey. Science, 1968, 162, 583-586.

Thompson, D. M.: Escape from S^D associated with fixed-ratio reinforcement. Journal of the Experimental Analysis of Behavior, 1964, 7, 1-8.

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