SECOND-ORDER AVOIDANCE BEHAVIOR IN MONKEYS¹J. D. FINDLEY², C. R. SCHUSTER³, AND J. ZIMMERMAN⁴

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Two monkeys were trained on a three-component multiple schedule using discrete trials. In one component (food), a response terminated a red stimulus and produced food and S^A. In the second component (avoidance), a response terminated a green stimulus and avoided shock. In the third component (optional), a response terminated a blue stimulus and produced S^A. The consequence of not responding in the blue stimulus, however, was the production of either a food or an avoidance trial. Manipulation of these consequences showed that when food trials were available only a small percent of the time after optional trials, the subjects tended not to respond in the blue, even though this led to an increase in the total number of avoidance trials per day. If only avoidance trials followed as a consequence of not responding in the optional component, the animals terminated the blue stimulus and avoided the avoidance trials. Throughout the experiment both subjects maintained consistently low shock rates (about 10 per day) and these were not affected by the various manipulations. The data suggest that a stimulus associated with avoidance can be a conditioned aversive stimulus and will maintain a more remote avoidance response under certain conditions.

Several studies have employed both positive and negative consequences for a given response. Earlier studies, such as Miller (1943) and Tolcott (1948), examined these multiple consequences in the context of "conflict". More recent studies, by Azrin (1960) and Azrin, Hake, Holz, and Hutchinson (1965), emphasize primarily the punishment aspect or simply view the behavior as under control of several variables. The present study is related to those mentioned above, and to a study by Hearst and Sidman (1961), in that a given behavior could lead both to positive and negative consequences. It also shows that by varying the preponderance of one or the other, the behavior could be increased or decreased. In the present experiment, however, non-emission of a given response class led to explicit contingencies for food or shock, while a positive emission of this response class precluded the possibility of either by produc-

ing S^A. This departure from the more usual arrangement of contingencies for programming "conflict" or multiple consequences led to what might be called a second-order avoidance behavior. The basic procedure for maintaining a second-order avoidance is probably independent of any procedural complications involving food reinforcement (*c.f.*, Field and Boren, 1965). Within the present experiment, however, the possibilities for food reinforcement may have indirectly facilitated its initial establishment. In recent studies by Sidman (1962), Verhave (1962), and Findley and Ames (1965), the aversiveness of stimuli associated with avoidance is suggested by the maintenance of escape responding from avoidance contingencies. The present study, in demonstrating an avoidance of avoidance performance, confirms and extends this general view.

Subjects and Apparatus

Two male mangabey monkeys, approximately 15 lb each, were restrained in a metal harness (Findley, 1959) modified to deliver electric shocks through the neck and waist bands. The monkeys were housed in separate, sound-attenuated chambers. They were seated in front of a panel containing stimulus lights, a lever manipulandum, and a food cup. Food pellets (Dietrich and Gamble, 0.67 g)

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were delivered automatically by a Foringer pellet dispenser mounted on the rear of the display panel. Cables were run from the display panel to an adjoining room where the experimental schedule was programmed automatically by relays, stepping switches, and timers. Shocks were generated by a Foringer device, No. 1154, set to give a 0.25-sec shock of 1.5 ma.

The Multiple Schedule

Each monkey performed on a three-component multiple schedule on alternate hours 24 hr a day. During "off" hours an overhead ceiling light and all panel lights were extinguished. During "work" hours, the ceiling light was on continuously and colored panel lights appeared as the discriminative stimuli for the trials within each component. The sequence of events during a "work" hour was as follows: 5 min S^A , a 10-min avoidance component, 5 min S^A , a 10-min food component, 5 min S^A , a 20-min optional component, and 5 min S^A . Each component of the multiple schedule was simply a group of given trials programmed as follows.

The avoidance component consisted of 10 1-min periods. The first 30 sec of each period was S^A , indicated by the presence of the dim ceiling light, and no lights on the display. After 30 sec had elapsed, a green light (avoidance trial) appeared on the display and remained on for a maximum of 30 sec. By depressing a lever the stimulus could be terminated and a possible shock avoided. If the lever was not depressed within the 30-sec period, the stimulus light terminated and a brief electric shock was delivered a given percentage of the time.

The food component also consisted of 10 1-min periods. The first 30 sec of each period was S^A . After 30 sec had elapsed, a red light (food trial) was presented for a maximum of 30 sec. If the monkey pressed the lever in the presence of the red light, the stimulus was terminated and a food reinforcement was delivered a certain percentage of the time.

The optional component consisted of 20 1-min periods. During the first 30 sec of each successive 1-min period, a blue light was presented for a maximum of 30 sec (optional trial). Failure to respond in the blue light resulted in either the green or the red stimulus with its usual reinforcement contingencies.

A response in the presence of the blue light terminated this stimulus, produced S^A , and thus avoided the food or the avoidance stimulus in the second half of the 1-min period. Positive responses in the blue are referred to as blue cut-off responses. Each optional trial then, consisted of a choice between responding in the presence of the blue stimulus, thereby producing S^A , or not responding, which would result in the appearance of either the food or avoidance stimulus.

Since the subjects were run on alternate hours, 24 hr per day, each was exposed to a total of 120 regular food trials, 120 regular avoidance trials, and 240 optional trials each 24-hr period. The total number of food and shock reinforcements possible per day was dependent in part upon the conditions programmed in the optional component.

Latencies, in seconds, from the onset of the red or green stimulus to the emission of a response, were separately recorded for the avoidance and food components. In the optional component, the frequency of blue cut-off responses was recorded in addition to the food and avoidance latencies (for those trials in which no response was emitted in the presence of the blue stimulus).

Experimental Manipulations

The subjects were run for approximately 125 days and several manipulations were performed. Most of them, such as altering frequency and intensity of shock associated with the avoidance trials, resulted in minor effects. Substantial effects, on the other hand, resulted from altering the probability of food trials after no response in the blue, and from altering the frequency of food reinforcement associated with food trials. The series of manipulations together with their effects are presented below.

RESULTS

Figures 1 (Subject S) and 2 (Subject C) summarize the experimental results. The top rows present the number of blue cut-off responses per 24-hr session; the middle rows present the mean latencies in all food and avoidance trials measured in seconds; and the bottom rows present the total number of food and shock reinforcements per 24-hr session.

Fig. 1. Measures of the behavior of Subject *S* under the various experimental conditions. Upper panel shows the total number of responses in the blue per 24 hr. Middle panel shows the mean latency for all food and avoidance trials. Lower panel shows total shock and food reinforcements per 24 hr.

The subjects were maintained under the baseline conditions for 45 days. Figures 1 (Subject *S*) and 2 (Subject *C*) show the results of only the last 10 days of this initial period. The baseline conditions were 50% food trials and 50% avoidance trials presented randomly after no responding in the blue; 25% food delivery for food trials; and 25% shock delivery set at 1.5 ma, for the avoidance trials. The number of blue cut-off responses can be seen to be consistently below 15 per 24 hr for both subjects throughout this period. The stability of the performance is demonstrated by both the food and avoidance latencies and the total number of shock and food reinforcements received per day.

The first change introduced was to substitute 30-sec S^{Δ} periods for the food periods in the optional component. Under these condi-

tions, failure to respond in the blue resulted in presentation of an avoidance period 50% of the time and an S^{Δ} period 50% of the time. The number of blue cut-off responses under this condition increased rapidly and steadily. Subject (*S*) can be observed to cut-off the blue on the order of 120 times out of a possible 240. It may thus be said to be avoiding the green on one-half of the available opportunities, when the probability of an avoidance trial after no response in blue is only 0.5, and when the probability of shock for failure to respond in the green is only 0.25. Subject (*C*) shows a higher frequency of blue cut-off responses, resulting in approximately 75% avoidance of the green. In both animals the latencies in the food and avoidance trials, as well as the frequency of shock reinforcement, are unaffected by this manipulation. The total

number of food reinforcements is diminished, since, by removing the food periods from the optional component, one-half of the total number of opportunities for food reinforcements was removed. To compensate for this loss, once each day each animal was given supplemental pellets to bring the total intake up to 60 pellets.

When the food periods were reinstated in the optional component (Day 21) the number of blue cut-off responses returned to its previous low level within a few sessions. The total number of food reinforcements per day increased with the subject's decreasing tendency to respond in the blue periods.

Shock intensity was then increased from 1.5 to 2.5 ma, and the shock frequency from 25% to 100% for failure to respond in the green. These manipulations slightly increased the number of blue cut-off responses for both subjects. Avoidance latencies for Subject (C)

decreased, while those for Subject (S) were not immediately affected. However, the decrease in the avoidance latencies seen in subsequent manipulations is probably attributable to this change in the avoidance schedule. The 100% shock frequency and increased intensity were maintained throughout the remainder of the experiment for all shock conditions.

The next three manipulations systematically increased the percent of times in which failure to respond in the blue resulted in the presentation of an avoidance period. (Concomitantly, of course, this decreased the percent of food trials after the blue). When these percentages were changed from a 50/50 ratio to 80% avoidance and 20% food, none of the behavioral measures changed. Further, when failure to respond in the blue resulted in 95% avoidance trials and only 5% food trials (day 50), no consistent behavioral

Fig. 2. Measures of the behavior of Subject C under the various experimental conditions. Upper panel shows the total number of responses in the blue per 24 hr. Middle panel shows the mean latency for all food and avoidance trials. Lower panel shows total shock and food reinforcements per 24 hr.

changes were observed, although both subjects briefly increased the number of blue cut-off responses. Unfortunately, on day 50 the percent of food trials in which a response was reinforced had also been increased (from 25% to 50%) to avoid having to give the animals supplementary food. This change in the food schedule confounded the results but may explain the lack of a sustained rise in the blue cut-off responses.

When the final change was made in this series (day 56), so that failure to respond in the blue resulted in avoidance periods 100% of the time (0% food trials), a marked increase was again observed in the number of blue cut-off responses. For both subjects the number of blue cut-off responses was higher under this condition than in the earlier manipulations where failure to respond in the blue led to 50% avoidance periods and 50% S^A periods.

Upon returning the schedule to 50% food periods and 50% avoidance periods (day 66) in the optional component, the number of blue cut-off responses again fell to its previous low frequency. The increased number of total daily food reinforcements, which can be observed for both animals, was a function of the prior change in percent reinforcement of food trials from 25% to 50%.

As a final manipulation we attempted to induce satiation by increasing the percent reinforcement of food trials from 50% to 75%. For Subject (S), as the total number of food reinforcements received per day rose, the number of blue cut-off responses rose substantially. Subject (C) failed to show any increment in blue cut-off responses under these conditions. However, when Subject (C) was pre-fed a large number of pellets for several days, the number of blue cut-off responses increased rapidly and steadily. Throughout all manipulations shock frequency was low and essentially static.

DISCUSSION

In all avoidance procedures, it is the non-emission (negative operant) of a given response class which produces the aversive event, and positive instances which produce a time out or "safe" period. In the present experiment, an option of this type (*c.f.* Findley, 1962) was arranged in the presence of the blue stimulus,

although non-emission of the response was not followed by a simple aversive event. Rather, it was followed by either classical avoidance or food reinforcement contingencies. Removal of the possibilities for food from this mixed consequence demonstrated its reinforcing effect upon not responding in the blue, since without food possibilities, not responding in the blue was no longer maintained. Positive emission of a response in the blue, on the other hand, always had terminated this stimulus and produced an S^A. Also, by virtue of the basic procedure, responses in the blue and green were equally effective in reducing shock frequency. The emergence of the second-order avoidance then, in the absence of food possibilities (or during satiation), would seem to be primarily a conditioned stimulus effect and related to two major factors. First, not responding in the blue produced a stimulus (green light) which occasionally was paired with shock, in spite of the general adequacy of avoidance in its presence. Secondly, responding in the blue produced a highly discriminable event, namely termination of the blue and production of S^A. The second-order avoidance, therefore, was probably obtained as a result of these factors and suggests a gradient of aversiveness declining from green to blue, and from blue to S^A. Review of the literature on Sidman-type avoidance with a warning stimulus (Sidman, 1955; Sidman and Boren, 1957; and Ulrich, Holz, and Azrin, 1964) shows responding before onset of a warning signal (and hence its avoidance) to be generally weak, unless the "warning signal" is an occasion for unavoidable shocks. In these studies, however, responses before the warning signal resulted in no exteroceptive stimulus change. On the other hand, Field and Boren (1963), using an adjusting avoidance procedure with a series of discriminable warning stimuli, found that rats would maintain a level of responding which kept them approximately three discrete stimulus steps away from shock. Their study, together with the present results, strongly suggests the feasibility of extensive multi-operant repertoires based upon less frequent and more remote primary aversive events. Advantages similar to those that have followed from chaining and complex schedule studies with food reinforced behaviors might reasonably be expected.

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