SOME NOTES ON "BURSTS" IN FREE-OPERANT AVOIDANCE EXPERIMENTS

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One method of programming a free-operant avoidance experiment is to permit each occurrence of a selected response to reset a self-recycling timer. If allowed to complete its cycle, the timer will deliver a shock to the subject (3). The most efficient behavioral adaptation to this situation would be for the subject to separate his avoidance responses by an interval just shorter than the setting on the timer. Under certain conditions, animals will approximate the optimal performance; but even efficiently spaced avoidance behavior is almost inevitably accompanied by a disproportionate number of closely spaced responses, i.e., "bursts" (4).

The rapid bursts of closely spaced responses in the free-operant avoidance situation have not been a subject of intensive investigation, and their sources remain a matter for conjecture. During this laboratory's program of research into avoidance behavior, a number of incidental, but relevant, observations have been made.

As a starting point, we may take the data from three rats, after extensive experience in the avoidance situation. The procedure was the same in all cases. Each lever-pressing response postponed a brief shock for 20 seconds (response-shock interval), and a recorder automatically tabulated interresponse times in class intervals of 2 seconds. Response probability was calculated by dividing the number of responses in a class interval by the number of occasions the animal paused long enough for that interval to be reached. For example, if the animal produced 100 pauses of 10 seconds or more since the preceding response, and on 50 of these occasions it responded during the class interval 10 - 12 seconds, probability during that class interval would be 0.50.

Figure 1 depicts response probability as a function of the length of pause. Shock occurs every time 20 seconds elapses without a response. All the rats display a relatively high order of efficiency, with response probability increasing markedly as the time for shock approaches. The likelihood of response immediately following the shock is also relatively high. Workers in several laboratories have noted that the responses just after shock tend to initiate bursts, and these could account in large part for the high probability of closely spaced responses. It should be noted that Rat SD-30, with a low response probability immediately after shock, displays a negligible number of bursts.

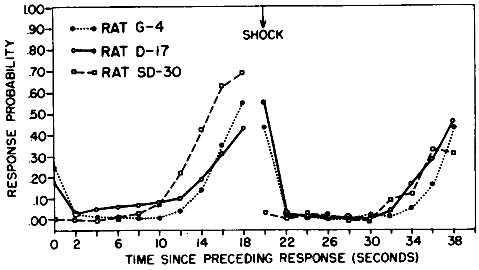

Fig. 1. Response probability as a function of the length of pause.

A clearcut instance of shock-produced bursts was observed in an experiment in which a monkey previously trained in lever-pressing avoidance behavior was given a brief unavoidable shock every 5 minutes. During this phase of the experiment, the avoidance contingency had been removed. That is to say, the animal received no shocks other than the unavoidable ones delivered every 5 minutes. Figure 2 is a cumulative record taken at a relatively late stage of the experiment. For present purposes, attention should be directed at the temporal pattern of responses as the over-all rate declines from its initial high level. During the period of over-all negative acceleration in the curve, most of the shocks are followed immediately by a rapid burst of responses. The burst usually ceases quickly, and the next shock generally follows a prolonged period of no response.

During the early stages of avoidance conditioning, shocks are often observed to initiate rapid bursts of responding. These bursts, combined with the gradual slowing of the response rate as extinction takes place, give the cumulative record the appearance of a series of small, negatively accelerated curves. In the monkey, the process can be exaggerated by programming a long response-shock interval as soon as the avoidance response has become conditioned. Figure 3 is a portion of a record taken when each response postponed shock for 3 minutes, following brief initial conditioning at short response-shock intervals. The bursts following shock are in marked contrast to the low rate that prevails immediately prior to shock.

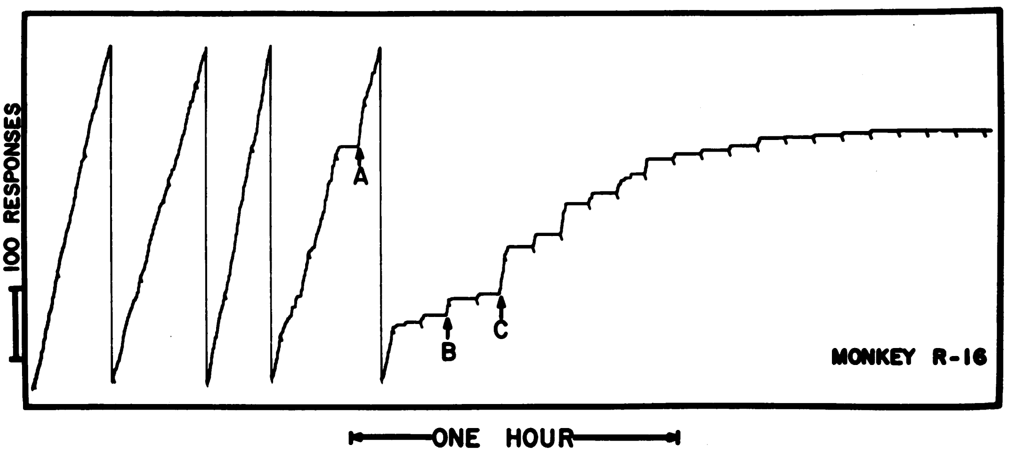

Fig. 2. Cumulative record taken during a late stage in a procedure in which an unavoidable shock occurred every 5 minutes. Small oblique lines indicate shocks.

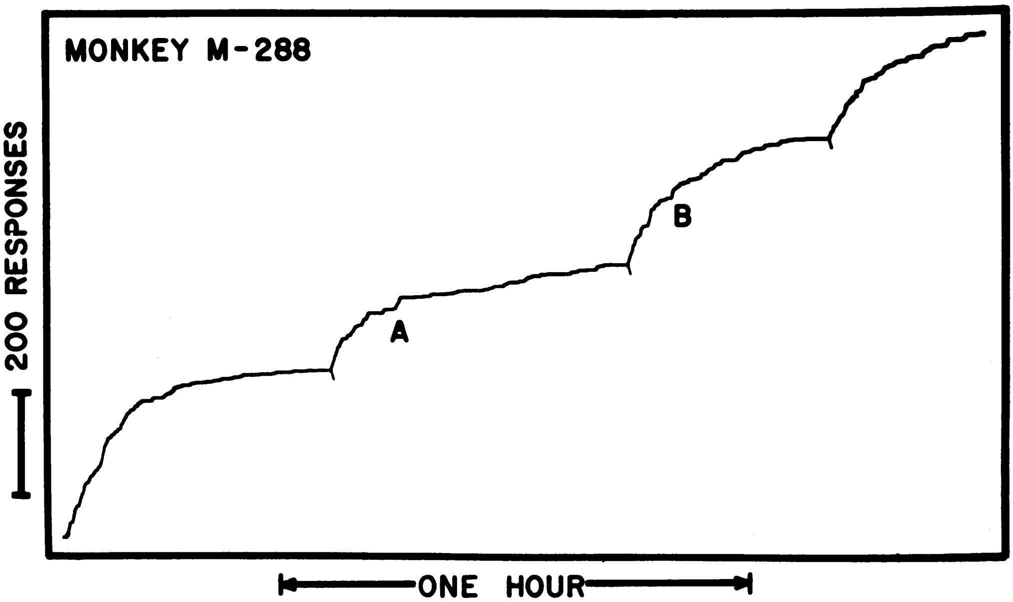

Fig. 3. Cumulative record illustrating negative curvature between shocks early in avoidance conditioning.

The correlation of shocks and bursts is fairly clear. Even a casual inspection of Fig. 3, however, will reveal a number of bursts several minutes after shock, as at A and B. There are a sufficient number of these to give each of the "negative scallops" a markedly ragged appearance. Similarly, in Fig. 2, at A, B, and C, relatively large bursts were initiated several minutes after the shock-produced bursts had ceased. Bursts apparently are not always correlated with an immediately preceding shock. There is some evidence to suggest that efficient responses, i. e., those which occur just before a shock would have been delivered, also serve to initiate bursts. An occasional animal displays this behavior in such extreme form that it is easily visible in the cumulative record, as in Fig. 4. This is a segment of an early record that shows a rat's lever-pressing behavior on a response-shock interval of 20 seconds. It consists of alternating bursts and pauses, and, if the bursts were not variable in length, would strongly resemble a fixed-ratio performance for food reinforcement. With a single exception, however, the bursts are initiated not by shocks, but by pauses that would have produced shocks if they had been prolonged for a few more seconds. Verhave, in personal correspondence with the writer, has also noted similar avoidance curves. Ferster, in an experiment in which chimpanzees avoided a "time out" from positive reinforcement, has also obtained records resembling Fig. 4, particularly in the early stages of conditioning (1).

The final case was provided by a monkey, avoiding shock on a type of discriminated-avoidance program (4). Each response postponed shock for 20 seconds, but a warning signal (clicking noise) was provided 5 seconds before a shock was

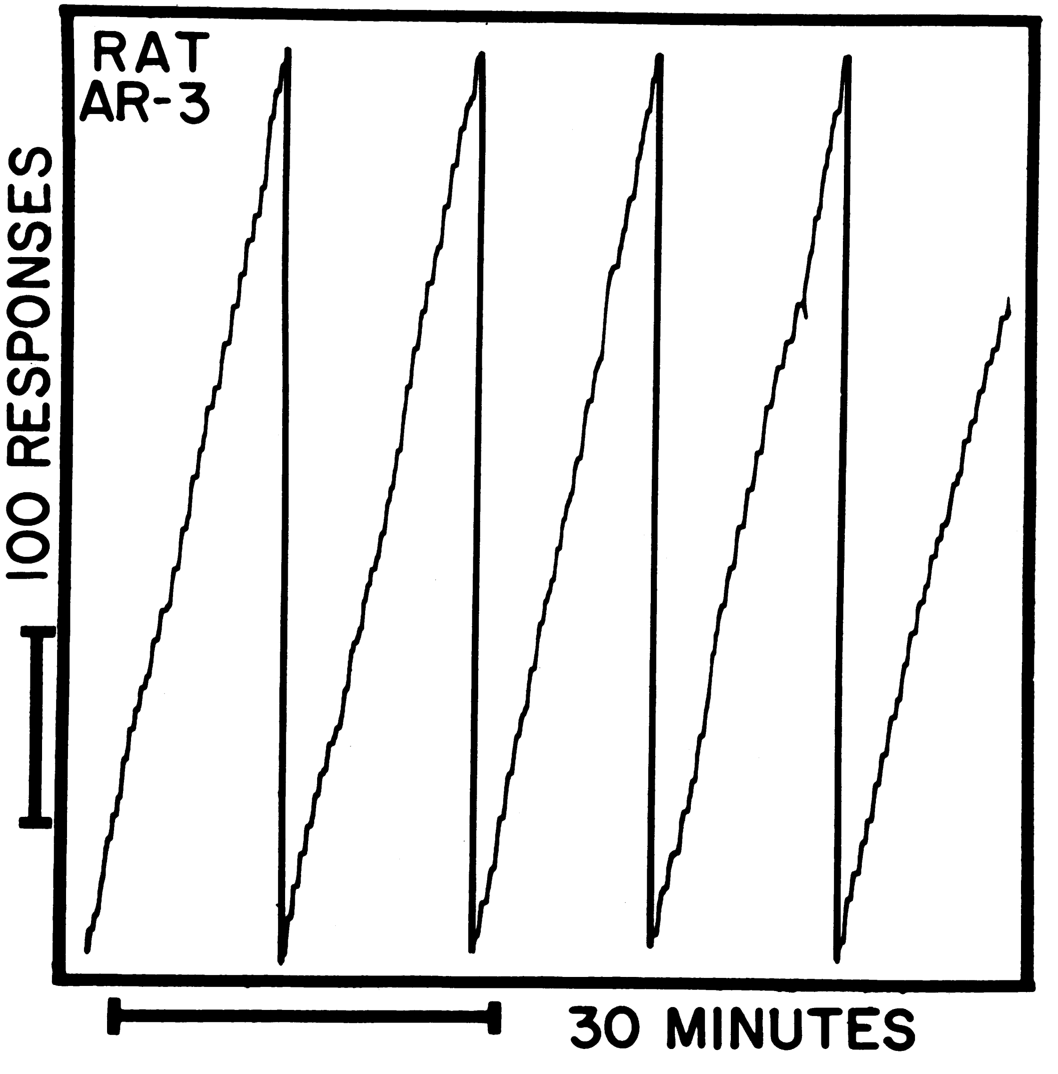

Fig. 4. Alternating bursts and pauses during avoidance conditioning.

due. That is to say, every time the animal waited 15 seconds without pressing the lever, the signal was presented. After 5 more seconds without a response, the signal terminated simultaneously with the delivery of a brief shock. Responses during the signal terminated it and postponed the shock, while responses prior to the signal postponed both it and the shock.

In the early stages of discriminated-avoidance conditioning, bursts were initiated by those responses that served to terminate the warning signal. This may be seen in the cumulative record of Fig. 5. The oblique markers on this curve represent stimuli only. All shocks were successfully avoided. In the late stages of conditioning, when the response rate in the absence of the warning signals had dropped to a low level, the bursts following stimulus termination were not nearly

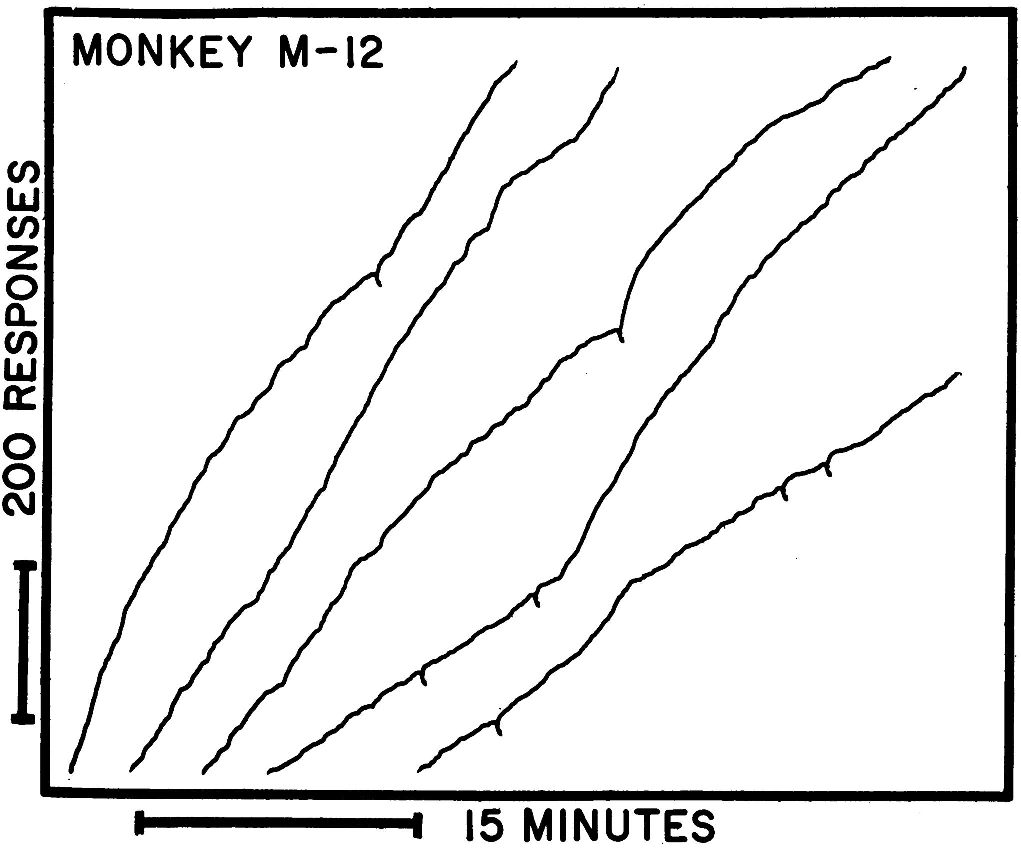

Fig. 5. Bursts initiated by responses that terminate warning stimuli. Small oblique lines indicate warning stimuli.

so pronounced as in Fig. 5, but they still tended to occur. Keller has described a similar phenomenon in rats that pressed a lever to terminate an aversive bright light (2). Intertrial responses tended to occur shortly after the escape responses.

Those bursts that do not follow shocks may be similar in origin to the bursts which are initiated by the termination of exteroceptive warning stimuli. If non-avoidance behavior with a punishment history can also serve as warning stimuli, the termination of such behavior by the avoidance response can possibly initiate a burst. Direct manipulation and observation of other behavior than the avoidance response will be required to check this suggestion. The possibility also exists that bursts occur through generalization from the "danger period," just prior to shock and during the warning signal, to the "safe period" that follows upon these events. I should like to pass along the conjecture that shocks and warning stimuli produce a temporary broadening of the generalization gradient.

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