Technical Papers

Avoidance Conditioning with Brief Shock and No Exteroceptive Warning Signal

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Experiments on avoidance behavior are usually divided, for the purpose of measurement, into trials. A trial, by definition, begins with the presentation of a warning signal and ends with the occurrence of the noxious stimulus or of the response which avoids the noxious stimulus. The measure, occurrence or nonoccurrence of the avoidance response, is necessarily a gross one since there are no intermediate states between the extremes. Traditionally, two expedients have been resorted to for circumventing this difficulty. Either the number of responses emitted by a group of organisms is averaged for each trial, or the trials for a single animal are grouped into blocks of arbitrary length and the number of responses averaged for each block. In the first case, a continuous measure is obtained only by virtue of the fact that progress is not uniform among organisms. The behavior of no individual can be described. With the second procedure, the type of relation obtained, if any, depends upon the number of trials included in each block. With both procedures, the statistical techniques result in the loss of a considerable amount of descriptive information. The purpose of the present paper is to report a technique which eliminates the above difficulties in investigating avoidance behavior, and to present an example of a kind of descriptive data which previous investigators in this area have generally neglected. Use of the rate measure, which is a natural one once behavior is freed from arbitrary constriction into trials, permits continuous observation and measurement of avoidance responding while providing a sensitive indicator of the effects of relevant variables (*1*).

White rats were the experimental organisms, with lever pressing selected as the avoidance response. Shocks of a fixed 0.2-sec duration were given to the animal through a grid floor at regular intervals unless the lever was depressed. Each lever depression reset the timer controlling the shock, thus delaying its appearance. If, for example, each lever press delayed the shock for 20 sec, a minimum interval of 20 sec was assured between avoidance behavior and shock. All other behavior was capable of being paired closely in time with the shock. Only the initial downward press on the lever reset the timer; holding the lever down had no effect upon the occurrence of the shock.

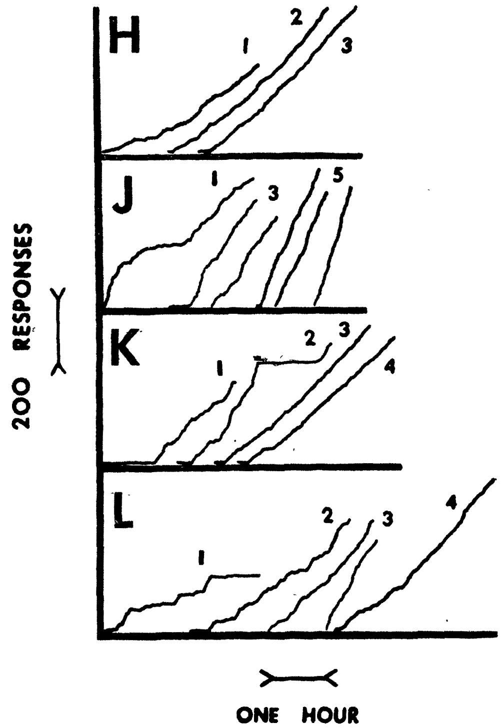

FIG. 1. Cumulative records of avoidance responding by 4 albino rats.

With no other contingencies between avoidance behavior and exteroceptive stimulation involved, approximately 50 animals have been successfully conditioned. Representative cumulated response curves for 4 of these animals are presented in Fig. 1. The letters refer to animals and the numbers to experimental sessions, each 3 hr in length. A striking characteristic of the initial curves is the abruptness with which the rate increases from its initial near-zero level. That these are not the unconditioned responses that hungry animals usually emit when the lever is first presented (*2*) was assured by making food and water continuously available to the animals in their home cages between experimental sessions, and by leaving the animals in the experimental cage, with the lever present, for 30 min before administering the first shock.

The initial curves are also characterized by their cyclic appearance and are composed of many small discontinuous segments. Responding of a more sustained nature is apparent as early as the final portion of the first session in some cases, but is most clearly demonstrated in later hours. With continued training the rate remains relatively stable not only within but also between sessions. Rates as high as 17 responses/min have been maintained by some animals during sessions totaling over 24 hr, with variations

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no greater than 0.1 responses/min appearing between the average rate for each session.

The behavior generated by this procedure can be explained by a model which holds that avoidance responding increases in rate at the expense of other behavior that is depressed by shock. An equivalent statement, in reinforcement terms, is that the avoidance response is strengthened when it terminates incompatible behavior that has been paired with shock (*3*, *4*). Several lines of evidence indicate that the avoidance rate is not simply some form of temporal conditioning in which the responses are triggered-off by the passage of a time interval. Once the response has developed, each occurrence automatically varies the interval between shocks. Furthermore, the relatively stable rates that finally emerge are considerably higher than are required by the shock schedule. If a temporal discrimination were to develop, it should, according to previous findings with the white rat in other situations, produce much more efficient responding than is displayed here (*5*, *6*). Mitigating against a time discrimination, once the avoidance behavior appears, is the fact that the animal is provided with no indication that the end of an interval is approaching. While the shock can mark the start of a time interval of, i.e., 20 sec, once a response occurs this interval increases. It is, in fact, possible to vary the delay produced by each response, so that the amount of increase is completely unpredictable, even if the organism were to be provided with an internal resetting timer.

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An Apparatus for Centrifugation and Washing of Particulate Matter in a Controlled Atmosphere

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In the course of an investigation of the ascorbic acid oxidase of the fungus *Myrothecium verrucaria* it was desired to treat a suspension of spores with isoascorbic acid in the absence of oxygen and subsequently to wash the spores while still excluding oxygen. The apparatus described herein was devised

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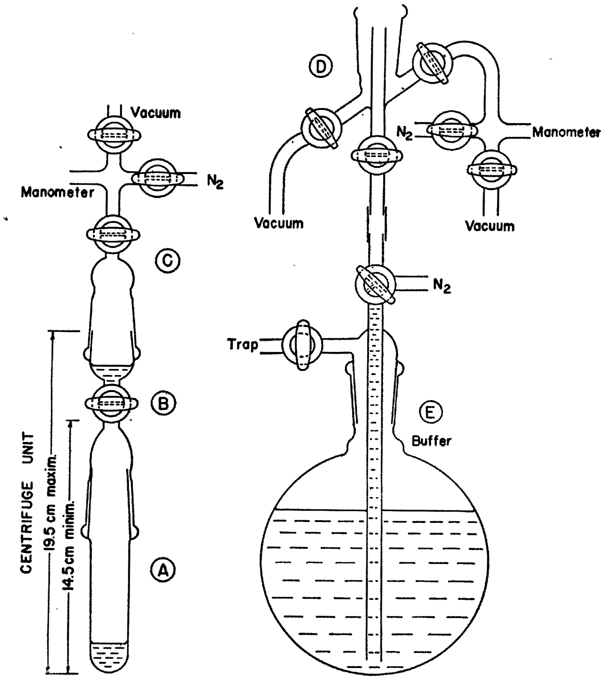

Fig. 1. Apparatus for washing cells in a controlled atmosphere by centrifugation; A–B, Centrifuge unit; C, Adapter for gassing centrifuge unit; D, Adapter for withdrawal of supernatant and admission of buffer; E, Reservoir of oxygen-free buffer.

and employed successfully for this purpose. A device of this type could find more widespread application and no comparable device has been encountered in the literature. The method can be used equally well for any gas mixture, and cells could be grown under pure culture conditions in the unit A-B. The apparatus is shown in Fig. 1. All joints are standard taper 24/40 with the exception of the male joint on B, which is shortened to a length of *ca.* 15 mm so as to clear the centrifuge head. An aliquot of spore suspension is placed in tube A. The adapter B is then seated and the whole freed from oxygen by repeated evacuation and flushing with nitrogen through adapter C. With nitrogen in A, the stopcock on B is closed, adapter C is removed, and 1 ml of isoascorbate added to the well above the stopcock on B. Adapter C is then replaced and the isoascorbate freed of oxygen as above. While the isoascorbate is under vacuum, stopcock B is opened slowly, allowing the nitrogen in tube A to bubble slowly through the liquid to remove final traces of oxygen. Nitrogen is now re-admitted to the system, forcing the isoascorbate into tube A and the stopcock on B is closed. The centrifuge unit A + B is removed, incubated at 30° for 1 hr, placed in a 100-ml Cornell-style metal centrifuge tube, which is then filled with water to cushion the unit, and centrifuged 15 min at about 1000 rpm. Upon removal of the tube from the centrifuge, it is inverted and inserted in the open female joint in D of the washing apparatus D-E, the sedimented material remaining at the top of the tube. The chamber in D is freed