Aspectus valvaris ellipsoidalis. In quoque apice frustulae chromatophorae duae magnae L-formes. Corpus magnum pyrenoideum agitationem brownianam argute exhibens. Sporae dormientes non visae (*2*).

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Notes

1. This study was supported by the Office of Naval Research. This report is a contribution of the Department of Oceanography and Meteorology, A. and M. College of Texas.
2. We gratefully acknowledge the courtesy of Dr. Lloyd H. Shinners, director of Herbarium, Southern Methodist University, in providing the Latin translation of the technical description of *Chaetoceros galvestonensis.*

2 April 1962

Intermittent Reinforcement by Removal of a Conditioned Aversive Stimulus

Abstract. Brief electric shocks were delivered at irregular time intervals but only while a light was on. A response was reinforced on a ratio schedule by the termination of the light. This method produced a high rate of response quite similar to that produced by a comparable schedule of food reinforcement.

An organism will maintain high levels of performance when positive reinforcement, such as food, is delivered only intermittently (*1*). In the method described here, intermittent reinforcement involving an aversive stimulus (electric shock) rather than food is used to maintain behavior.

Five squirrel monkeys were subjects. In the first phase of the procedure a brief (0.3-second) electric shock was delivered to the monkeys through a floor grid at irregular intervals of time as long as the experimental chamber was illuminated by a dim white light. When the chamber was darkened, no shocks were delivered. In the second phase, the subject could terminate the light (conditioned aversive stimulus) for a period of 2 minutes by pressing a wall-mounted lever. This phase is shown in the left section of Fig. 1. Thus far, the procedure differs from the classical avoidance procedure of Bechterev (*2*) mainly in that the conditioned stimulus can be terminated only by a response. It should be noted that the termination of the light was ineffective as a reinforcer unless the light had been previously paired with the shock.

In the third phase, the number of responses (ratio requirement) necessary to terminate the conditioned stimulus was gradually increased. The subject now had to press the lever several times to remove the conditioned stimulus, as shown in the right section of Fig. 1. These changes in the ratio requirement produced characteristic changes in the frequency, as well as in the temporal pattern of responding (Fig. 2). At ratio requirements less than 50 responses, the subject began to press the lever almost as soon as the light appeared. The subject maintained a high rate of approximately four responses per second until the light was turned off. At ratio requirements up to five responses, only one or two shocks were delivered during each 6-hour session since the light was turned off within a few seconds after its appearance. As the ratio requirement was increased, little or no responding occurred immediately after the light appeared. This "pause" was as short as a second or so at ratio requirements below 50 and as long as 20 minutes at the ratio requirement of 350 responses. After each pause, the subject abruptly began to respond at a high rate and maintained this rate until the light was turned off. Similar changes in responding have been found when a response ratio terminated an unconditioned, rather than a conditioned aversive stimulus (*3*). On the other hand, a ratio requirement did not produce this pattern of "pauses" and "runs" when no stimulus change resulted at the completion of the ratio (*4*). Fixed-ratio reinforcement has been demonstrated recently by Sidman (*5*) when the reinforcement consists of escape from an avoidance situation.

At the low ratio requirements, the animal pressed the lever at such a high rate that there was never more than a small fraction of a second between any two responses (see Fig. 2). When shocks occurred, they were necessarily within a fraction of a second after a response. In spite of this virtual punishment of individual responses, the subject continued to respond at a high rate. Therefore, the removal of the stimulus associated with shock appeared to be the primary source of reinforcement; the immediate relation of the shock to the responses appeared to be distinctly secondary in maintaining the behavior. Hence, the present procedure differs from the Sidman avoidance procedure (*6*) in which the primary relationship is between the shocks and the responses.

Once this pattern of behavior is well established, the shocks could be scheduled as infrequently as ten per hour with relatively little loss of behavioral control. Also, there is only a slight reduction of responding when the escape duration is reduced to as little as 30 seconds. Hence, the procedure produces a large amount of behavior with very few electric shocks and very brief escape periods. The results described above were typical of all five subjects studied.

The pattern of responding under this procedure is comparable in every major respect to the pattern of responding that is obtained with fixed-ratio positive reinforcement. Both schedules generate exceptionally high levels of responding. In both procedures, the pattern consists of a pause after reinforcement followed by a high and constant terminal re-

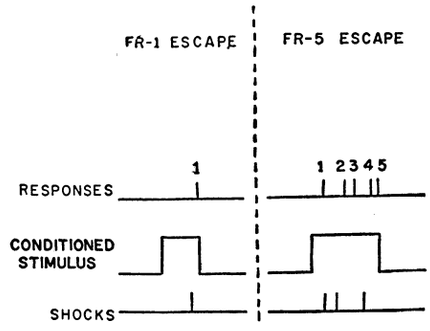

Fig. 1. Diagrammatic representation of the experimental procedure (see text).

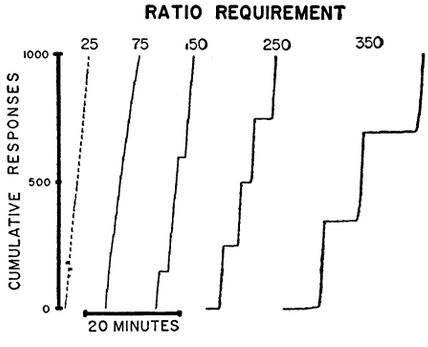

Fig. 2. Escape from conditioned aversive stimulation by one monkey. Each segment is a sample cumulative record of the responses under various ratio requirements. The oblique pips indicate a 2-minute escape period during which time the conditioned aversive stimulus was removed. The recording paper did not move during this interval. Brief shocks (not indicated) were delivered at variable intervals (average: one every 3 minutes) during the conditioned stimulus.

sponse rate. Similarly, the duration of the pause in both procedures is a direct function of the ratio requirement. The procedure provides a means of investigating other schedules of intermittent reinforcement by the removal of conditioned aversive stimulation (*7*).

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8 December 1961

Absence of Carbon-14 Activity in Dolomite from Florida Bay

Abstract. A sample of dolomite crystals concentrated from Recent carbonate sediments in Florida Bay gave a carbon-14 age greater than 35,000 years. Since Recent sedimentation in Florida Bay began less than 4000 years ago, the dolomite must be derived from older rocks, and Taft's hypothesis that dolomite is forming today is incorrect.

The occurrence of dolomite crystals in the Recent carbonate sediments in western Florida Bay was recently reported by W. H. Taft, who expressed the opinion, based on textural evidence, that the dolomite had been formed by Recent diagenesis (*1*). Because Taft also observed that the sediments contained quartz grains of approximately the same size as the dolomite crystals, there is the possibility that the dolomite, like the quartz, is clastic material derived from older rocks. Since the episode of Recent sedimentation in Florida Bay began about 3000 to 4000 years ago (*2*), it is possible to test whether the dolomite is of Recent origin by determining the carbon-14 content of the carbonate from the dolomite. The fact that dolomite separated from one sample of Florida Bay sediment showed no measurable carbon-14 activity indicates that the dolomite in this sample was of detrital origin.

A surface sample of about 3000 grams of carbonate sediment from Ox Foot Bank at the western end of Florida Bay (near latitude 25°00′ N, longitude 81°00′ W) was collected by Eugene Shinn. Dolomite crystals similar to those described by Taft were present in the sample. The sediment was separated into size fractions by wet sieving for the particles coarser than 44 μ and by repeated decantation for the finer sizes. Preliminary x-ray diffraction examination showed that the sample consisted mostly of aragonite and calcite with minor amounts of dolomite and quartz, and that the largest concentration of dolomite was in the 20- to 75-μ sizes. The 20- to 75-μ material was treated by adding dilute hydrochloric acid gradually, and x-ray diffraction runs were used to determine when the aragonite and calcite had been reduced to less than 1 percent of the amount of dolomite in the concentrate. During the acid treatment, the approximately constant ratios of x-ray peak heights between dolomite and quartz indicated that at least 90 percent of the dolomite present at the beginning was recovered. For the carbon-14 determination, the dolomite concentrate was treated with an excess of strong acid to evolve carbon dioxide, and the residual liquid was analyzed for calcium and magnesium by Versenate titration. The molar ratio of calicum to magnesium was 1 to 1.03, which indicates that, within the accuracy of analysis, the material dissolved for the carbon-14 measurement was composed entirely of dolomite. The amount of calcium and magnesium in the residual liquid showed that 6.7 g of dolomite were converted to carbon dioxide.

Carbon-14 counting, carried out 30 days after the sample preparation to allow a minor amount of radon activity to decay, showed that the dolomite contained no measurable carbon-14 activity. The count rate observed for the dolomite sample and background determinations made before and after agreed within the 2-percent error expected from the counting statistics. The age of the dolomite must be greater than 35,000 years, because a sample younger than this would have given a count rate different from the background rate by two standard deviations. Stated in another way, the carbon-14 determination was sufficiently sensitive to have detected a significant difference in count rate if as much as 2.4 percent of the sample had been as young as 4000 years.

Carbon-14 ages on the bulk carbonate sediment in the original sample gave 1750 ± 150 years, and the coarse shell fragments separated from the sample gave 1660 ± 130 years. If the dolomite crystals had grown in this environment during the last few thousand years, they would have had access only to carbonate that contained the usual amount of carbon-14 activity. Therefore it must be concluded that the dolomite crystals are derived from older rocks and mixed with the Recent sediment. Because the presence of carbon-14 activity would be a positive demonstration of the Recent origin of a carbonate material, it is suggested that the radiocarbon measurement used for the dolomite from the Bonneville salt flats by Graf *et al.* (*3*) is a much more reliable means of identifying a recently formed carbonate mineral than is the textural evidence used by Taft (*1*) and more recently used by Miller (*4*).

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26 December 1961

Carbon Dioxide Fixation in Lobster Nerve

Abstract. Aspartic, glutamic, malic, and citric (isocitric) acids were isolated by chromatographic methods from lobster nerves incubated with Ringer's solution containing C^{14}-bicarbonate. All the compounds were labeled; the bulk of the radioactivity appeared in the aspartic acid. The findings suggest the operation in lobster nerves of the citric acid cycle including CO_2 fixation.

In nerve, carbon dioxide has long been regarded as a regulator of its internal *p*H; in addition, it produces an increased membrane potential (*1*). Recently, a significant carbon dioxide fixation, presumably via the citric acid cycle, has been demonstrated in vivo in the mammalian brain. Intracarotid infusion into cats of C^{14}-bicarbonate resulted in labeling of cerebral glutamic and aspartic acids and of glutamine (*2*).

This finding raised the question as to whether carbon dioxide fixation is a general metabolic property of nervous