AVOIDANCE BEHAVIOR AND THE DEVELOPMENT OF GASTRODUODENAL ULCERS

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Observations in our laboratory over the past year or more have revealed the development of extensive gastrointestinal lesions in a series of some 15 monkeys restrained in chairs and subjected to a variety of prolonged behavioral conditioning and/or intracerebral self-stimulation experiments (1). The behavioral studies focused upon emotional conditioning procedures of the "fear" or "anxiety" type, and upon avoidance of noxious electric shocks to the feet. Intracerebral self-stimulation through chronically implanted electrodes involved various limbic-system structures. While the program for each animal in this initial series varied considerably, all were subjected to intensive experimental study for at least 2 to 8 weeks. Five control monkeys, subjected only to restraint in the chair for similar periods, however, showed no gastrointestinal complications.

The present report describes the results of an experiment designed to define some of the more specific behavioral factors contributing to the etiology of this lethal pathological picture. Eight rhesus monkeys, restrained in chairs, as illustrated in Fig. 1, were divided into pairs and conditioned according to a "yoked-chair" avoidance procedure. Each pair of monkeys received brief electric shocks (5 milliamperes, 60-cycle AC, for 0. 5 second) to the feet from a common source every 20 seconds unless the experimental animal of the pair pressed a lever which delayed the shock another 20 seconds for both animals (2). Inactivation of the lever available to the control animal insured an equal number and temporal distribution of shocks to both monkeys ("physical trauma"), while providing the avoidance contingency for only the experimental animal. Each pair of monkeys received 6-hour sessions on this procedure, alternating with 6-hour "off-periods" (no shocks) 24 hours each day for periods up to 6 or 7 weeks. A red light was illuminated in plain view of both animals during the 6-hour "avoidance" periods, and was turned out during the 6-hour off-periods. The experimental procedure was programmed and the animals' behavior recorded automatically by timers, magnetic counters, cumulative-work recorders, and associated relay circuits. Lever responses and shocks were recorded continuously for all animals, and separate counts were maintained for the avoidance periods and for the off-periods. Throughout the entire experiment, urine was collected continuously from all animals in 24- or 48-hour samples for 17-hydroxycorticosteroid determinations.

J. exp. anal. Behav. 1958, 1 (1).

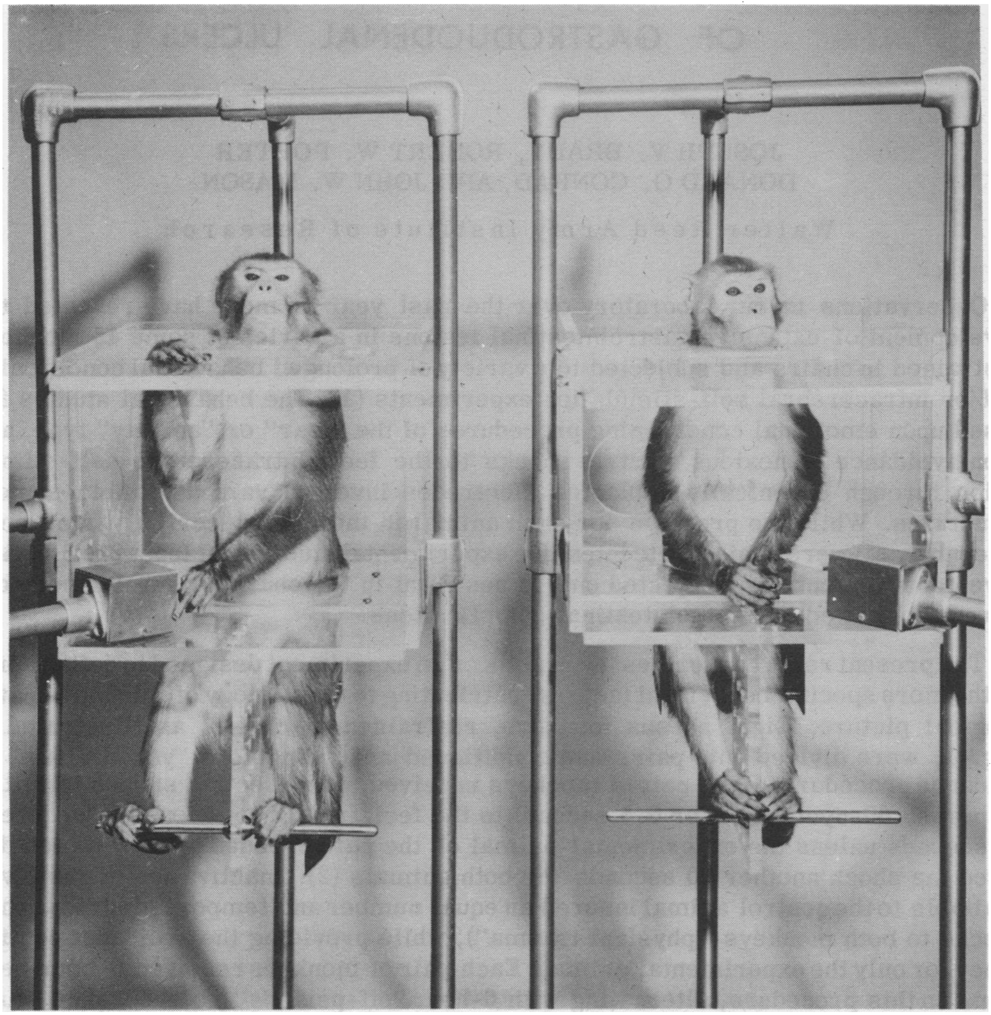

Fig. 1. An experimental monkey and a control monkey, gently restrained in primate chairs, illustrate the "yoked-chair" avoidance situation. The lever available to each animal is shown within easy reach, although only the experimental "avoidance" monkey on the left is observed to press the lever.

The avoidance behavior was trained initially during two preliminary daily sessions of 2 to 4 hours. The training procedure involved the use of a short 5-second interval between shocks in the absence of a lever response (the "shock-shock" or "S-S" interval) and a 20-second interval between lever responses and shocks (the "response-shock" or "R-S" interval). At the outset, a lever response by either animal of a given pair delayed the shock for both animals and no further "shaping" of the behavior was attempted. Within the first preliminary session, however, one monkey of each pair was observed to develop avoidance lever-pressing before its partner and was selected as the experimental animal. At this point in the preliminary training procedure, both the "shock-shock" and the "response-shock" intervals were set at 20 seconds and the control monkey's lever was made ineffective with respect to avoiding shocks for the remainder of the experiment.

Within a few hours after the initiation of the alternating 6-hour sessions, the experimental animals of each pair had developed stable avoidance lever-pressing rates (Fig. 2) which showed little change throughout the experiment. Responses during the 6-hour off-periods in the absence of the red light rapidly dropped to a low level, as shown in Fig. 2, and also remained there throughout the experiment. Since the lever-pressing rates for the experimental animals during the 6-hour avoidance periods approximated 15 to 20 responses per minute, the behavior effectively prevented all but an occasional shock for both animals throughout the alternating 6-hour "on-off" cycles of any given 24-hour period. The shock rates never exceeded 2 per hour during the 6-hour avoidance periods, and typically averaged less than 1 per hour. For the most part, only somewhat variable "operant

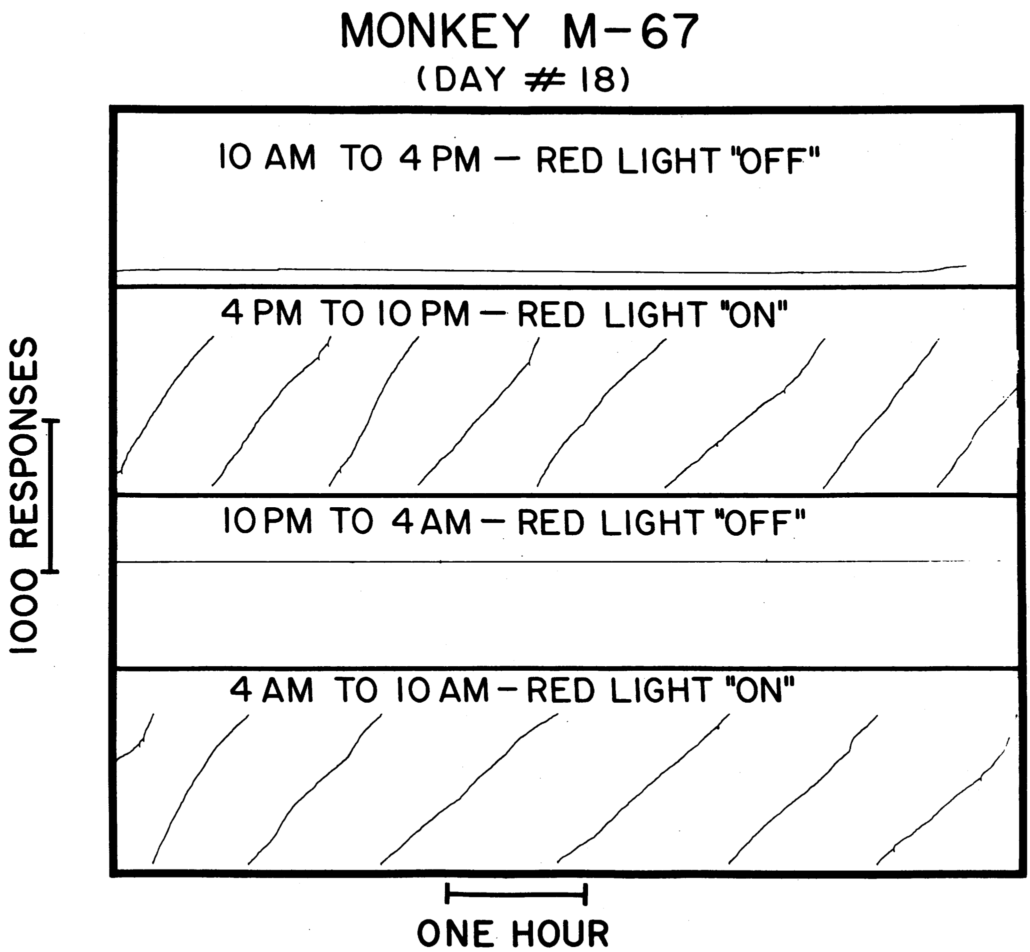

Fig. 2. A sample cumulative-response curve showing one 24-hour session (alternating 6-hour "on - off" cycles) for experimental "avoidance" monkey M-67 on day No. 18. The oblique "pips" on the record indicate shocks.

levels" of lever-pressing were maintained by the control animals of each pair, although one of these animals did appear to develop what might be termed a "superstitious avoidance" rate during the 3-week alternating procedure. From an initial rate not exceeding 1 response per hour during the first few days on the procedure, this control monkey gradually increased his output to 2 responses per minute by the 10th day, and ultimately reached a peak of 5 responses per minute on the 20th day. During the succeeding 5-day period, however, his rate again gradually declined to relatively high levels of considerably less than 1 response per minute. Throughout this entire period, the experimental animal of this pair maintained a lever-pressing response rate of almost 20 responses per minute.

Measurement of the urinary excretion of total 17-hydroxycorticosteroids (17-OH-CS) at selected stages during the experiment revealed slight increases in the 24-hour 17-OH-CS output in both monkeys of each pair during the initial phases of avoidance conditioning. Otherwise, the samples tested in subsequent phases of the experiments showed no evidence of increased adrenal cortical activity, as judged by the 24-hour 17-OH-CS excretion. Fluctuations outside the normal range which may have occurred within individual 6-hour avoidance or rest periods cannot, however, be excluded by the data on 24-hour urine portions.

With the first pair of monkeys, the death of the avoidance animal after 23 days terminated the experiment during one of the 6-hour avoidance periods. With the second pair, the avoidance monkey again expired during one of the 6-hour "on-periods," this time 25 days after the start of the experiment. With the third pair in this series, the death of the experimental animal again terminated the experiment during one of the avoidance cycles, this time only 9 days after initiation of the alternating 6-hour on-off procedure. And the experimental animal of the fourth pair of monkeys was sacrificed in a moribund condition after 48 days on the avoidance procedure. In all instances, gross and microscopic analysis revealed the presence of extensive gastrointestinal lesions with ulceration as a prominent feature of the pathological picture in the experimental animals. However, none of the control animals sacrificed for comparison with their experimental partners and subjected to complete post-mortem examination, showed any indications of such gastrointestinal complications.

The results obtained with this technique, while consistent with previous reports of experimentally produced "psychosomatic" conditions (3), must be considered only as the initial findings of a programmatic effort to systematically define the variables of which this phenomenon may be a function. Follow-up studies, presently in progress, strongly suggest that selection criteria for experimental and control animals, relative degrees of "social contact" or isolation during the experiment, and possibly even constitutional factors may play a critical role in the development of gastrointestinal pathology as a consequence of such "behavioral stress."

REFERENCES

1. Porter, R.W., Brady, J.V., Conrad, D.G., and Mason, J.W. Occurrence of gastrointestinal lesions in behaviorally conditioned and intracerebral self-stimulated monkeys. *Federation Proc.*, 1957, 16, 101-102.

2. Sidman, M. Avoidance conditioning with brief shock and no exteroceptive warning signal. *Science*. 1953, 118, 157-158.

3. Sawrey, W. L., Conger, J. J., and Turrell, E.S. An experimental investigation of the role of psychological factors in the production of gastric ulcers in rats. *J. comp. phsyiol. Psychol.*, 1956, 49, 457-461.