Cold Exposure and Heat Reinforced Operant Behavior

Abstract. Six rats, working in a 2°C ambient temperature, were trained to depress a lever to receive a brief period of heat. Four rats were then moved into the 2°C environment to live, while the others continued to live at room temperature. Living at a temperature of 2°C increased the number of heat presentations the animals delivered to themselves.

This report provides a brief description of an experiment (*1*) on the use of a behavioral index of the effects of cold exposure. In a variation of the operant conditioning setup (see *2*), brief periods of heat were delivered to cold-exposed rats, rather than food or water to deprived ones, as reinforcement for the response of depressing a small lever (*3*).

The establishment of stable lever-pressing behavior can be divided into three phases. In the first, the animals (adult, male, Sprague-Dawley rats) were placed in a small response chamber, at an ambient temperature of about 2°C, for 1 hr. Throughout the session 10-sec periods of heat (about a 15°C rise) were presented at the rate of two per minute. The response chamber was heated by the application of voltage to heating coils mounted just below the hardware-cloth floor. A continuous, slow-speed fan below the coils accelerated the passage of heated air into the chamber during the 10-sec "heat time" and cooled it at the end of this period. Throughout each period of heat presentation, a tone of intermediate frequency and moderate intensity was also delivered. The apparatus was housed in a larger refrigerated room maintained at approximately 2°C. The fully automatic control and recording devices were housed in a separate room.

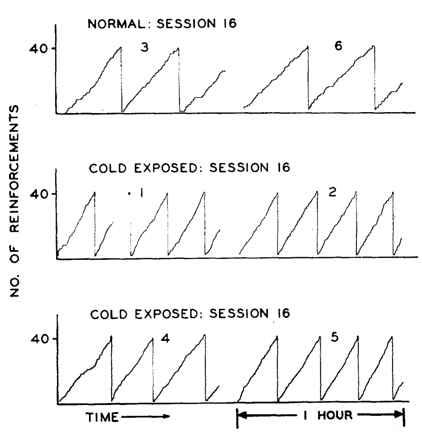

Fig. 1. Reinforcement rates for individual rats after 16 daily sessions. Each record is 1 hr long. The "normal" animals (Nos. 3 and 6) lived at room temperature throughout the experiment; the "cold-exposed" animals (Nos. 1, 2, 4, and 5) lived at a temperature of 2°C from the sixth to the 16th day. Conditions throughout the session were the same for both groups. The gap in the record for rat No. 1 was caused by a faulty pen.

At the end of the 1-hr session, the rat was returned to its cage in the colony room, maintained at about 20°C, where the animal had continuous access to food and water.

The second phase of training began the next day. A T-shaped lever, parallel to the floor and 2 in. above it, had been inserted into the chamber. During this 1-hr session, depressing the lever produced the 10 sec of heat and tone. We found that, unless some such stimulus as the tone was paired with each heat presentation, stable lever pressing could not be established. Depressions made *during* the 10-sec "heat time" had no effect on the duration of the current presentation or on the presentation of subsequent heat periods.

The third daily 1-hr session was divided into two half-hour segments. The conditions of the first half-hour were identical to those of the second session. The speaker that delivered the tone was then disconnected. From this point on (the beginning of the third training phase), each lever depression delivered 10 sec of heat unaccompanied by any other stimulus. The third phase was continued for three additional 1-hr daily sessions. The details of the apparatus and of a similar procedure have been presented elsewhere (*4*).

We have used the behavior so generated as an index of the effects of prolonged exposure to cold. Because we were primarily concerned with changes in the way in which the animal "heated itself," our basic datum was the rate at which reinforcements were delivered rather than the response rate. These two measures are not identical, since the animal could, and did, respond during any 10-sec period of heat presentation—that is, response rate was greater than reinforcement rate. The reinforcements were plotted by a cumulative recorder. The pen reset to the base line after 40 reinforcements.

Following the sixth daily session, four randomly selected animals (Nos. 1, 2, 4, and 5) were moved into an ambient temperature of 2°C, while two others (Nos. 3 and 6) continued to live at room temperature. The daily 1-hr lever-pressing sessions were continued as usual. In session 6, the average reinforcement rate for rats No. 1, 2, 4, and 5 was 0.58 reinforcements per minute; for rats No. 3 and 6 it was 1.03 per minute.

The data shown in Fig. 1 are for session 16, 10 days after the exposed animals began to live in the cold. It will be seen that all animals "deliver" heat to themselves at a roughly constant rate throughout the session; this is apparent in the over-all linearity of the records. It is also clear that the reinforcement rates for the cold-exposed animals are markedly higher, in all cases, than are those for the control animals. The average reinforcement rate for the exposed animals is 2.8 reinforcements per minute; for the control animals it is 1.7. Relative to their performance in session 6, then, the average rate for the exposed animals increased by about 2.2 reinforcements per minute, while that for the controls increased by 0.7 per minute.

The session-to-session course of this rise in reinforcement rate for other rats, as well as the relationships among reinforcement rate, body weight, and food consumption, has been reported elsewhere (*5*).

Peter L. Carlton*
Ronald A. Marks†
U.S. Army Medical Research Laboratory, Fort Knox, Kentucky

References and Notes

1. The experiment was conducted at the U.S. Army Medical Research Laboratory, Fort Knox, Ky. The opinions expressed are entirely ours and do not necessarily reflect those of the Office of the Surgeon General or the Department of the Army.
2. B. F. Skinner, *The Behavior of Organisms* (Appleton-Century-Crofts, New York, 1938).
3. A similar procedure, in which a different means of heat delivery was used, has been described by B. Weiss ["Thermal behavior of the subnourished and pantothenic-acid-deprived rat," *J. Comp. Physiol. Psychol.* 50, 481 (1957)].
4. P. L. Carlton and R. A. Marks, *USAMRL Rept. No. 299, Fort Knox, Ky.* (1957).
5. ———, *USAMRL Rept. No. 325, Fort Knox, Ky.* (1957).

* Present address: The Squibb Institute For Medical Research, New Brunswick, N.J.
† Present address: Department of Psychology, Washington University, St. Louis, Mo.

10 July 1958

Influence of Hexane Solubles in Tobacco on a Polycyclic Fraction of Cigarette Smoke

Abstract. No variation in total amounts of those polycyclic hydrocarbons with ultraviolet absorption maxima at 385 mμ was found in the smoke from cigarettes containing varying amounts of hexane solubles. Addition of C^{14}-labeled tobacco paraffins to cigarettes showed that tobacco paraffins are unimportant as precursors of polycyclic hydrocarbons in smoke.

Removal of waxes from tobacco by a "dry cleaning" or extraction with a low-boiling solvent such as hexane has been suggested as a means of reducing the amounts of polycyclic hydrocarbons in cigarette smoke. Lam (*1*) demonstrated the formation of polycyclic hydrocarbons on pyrolysis of tobacco paraffins at temperatures higher than 600°C. Campbell and Lindsey (*2*) reported that extraction of cigarettes with cyclohexane reduced the amounts of polycyclic hydrocarbons by more than 50 percent, but they obtained similar results on extraction of paper cigarettes, and paper contains little or no material soluble in cyclohexane. Gilbert and Lindsey (*3*)