Cardiac conditioned responses in avoidance and yoked-control rats[1]

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Rats in a yoked-control group were paired with partners which were given avoidance conditioning and extinction. Both animals received simultaneous and identical presentations of the CS and US throughout training. Heart rate data revealed that inter-trial rates declined over sessions for both groups. The cardiac responses to the CS increased in magnitude in the avoidance group over acquisition sessions as CARs increased in frequency. In the yoked-control group, however, the cardiac response diminished over sessions.

The present study was designed to measure cardiac rates in rats during aversive conditioning with a method which would attempt to differentiate between the "emotional" and motor aspects of the training. One group of animals received avoidance training. The second group was paired individually with avoidance rats in a yoked-control fashion such that the animals received the same exposures to the CS and US.

Apparatus

Avoidance training was conducted in a shuttlebox (Murphy & Miller, 1955), while yoked controls were run in a similar box equipped with a partition at midline to prevent crossing responses. Each box was supplied with its own shock supply and scrambler calibrated to provide identical shocks (0.75 mA). The CS was a 24 V buzzer located at midline of each box.

Heart rates were recorded from electrodes mounted on a lightweight saddle of plastic and spring copper which was attached to the rat at the start of a test session (Snapper, Ferraro, Schoenfeld, & Locke, 1965).

Procedure

Thirty-four male Carworth rats between 100 and 120 g were assigned randomly to two groups. The rats were housed and tested in pairs. Ten conditioning trials were given daily with an average intertrial interval of 60 sec. Heart rates were recorded for 6 sec prior to each CS and during the 6 sec CS period. Shock was delivered via the grid floor at the end of the CS period if a hurdle crossing response (CAR) had not occurred and shock was continued until the avoidance rat did cross the hurdle into the adjoining compartment (UR). When a CAR did occur, the CS was immediately terminated for both Ss.

Acquisition sessions were given daily until the avoidance partner met a criterion of 80% CARs for three consecutive sessions. Then extinction was begun and continued until a criterion of 20% CARs were performed for three consecutive days.

Results

Three avoidance rats failed to achieve one of the criteria within an arbitrary limit of 30 sessions and, with their control partners, were dropped. The results are based on 14 pairs of animals.

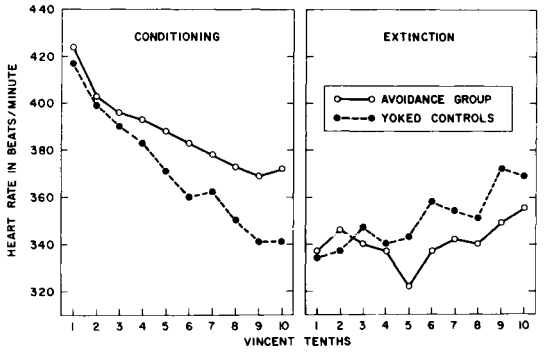

Fig. 1. Pre-stimulus heart rate level in the two groups of rats during acquisition and extinction.

The median number of trials to acquisition was 70 (range 50-170) and to extinction was 45 (range 30-170). Since the individual pairs were tested to criterial performance and, since it was of interest to examine heart rate response as a function of the acquisition of CARs, the data were vincentized for purposes of analysis. The number of heart beats in the 6 sec preceding CS and the number during CS were counted for each trial. The conditioned cardiac response was obtained by subtracting the pre-CS from the CS count.

Figure 1 shows the trends in pre-CS rate during conditioning and extinction. A repeated measures analysis revealed that pre-CS rate decreased in both groups during conditioning ($p < .001$). The groups did not differ from each other. In extinction there was an increase in pre-CS rate over trials ($p < .001$) and, again, the groups did not differ. A t test indicated that the abrupt drop in rate between the end of acqui-

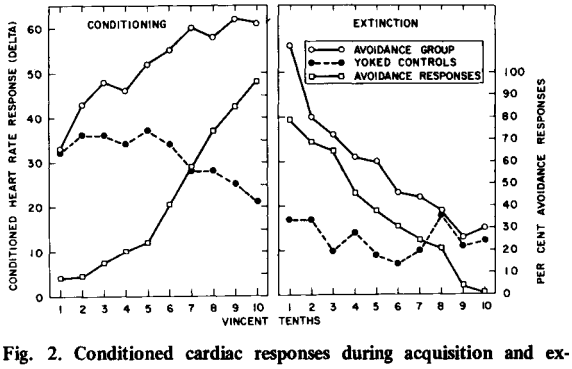

Fig. 2. Conditioned cardiac responses during acquisition and extinction.

sition and the start of extinction in the avoidance group was significant ($p < .01$).

Repeated measures analyses of the conditioned cardiac response (Fig. 2) revealed that the groups differed in magnitude of response ($p < .001$) and in trend ($p < .001$) during acquisition. So, too, in extinction the groups ($p < .001$) and trends ($p < .001$) differed.

Discussion

The results indicated that in both the avoidance and the yoked-control groups there was a decrease in pre-CS heart rate over acquisition sessions. Reports on habituation of heart rate in the rat to novel but innocuous environments indicate that it is a very slow process (Black, Fowler, & Kimbrell, 1964; Candland, Pack, & Matthews, 1967; Snapper, Ferraro, Schoenfeld, & Locke, 1965). Since the animals in this study showed rapid and progressive decreases in rate, and, since noxious stimuli were involved which should reduce the chances for habituation, it seems reasonable to suggest that the drop in pre-CS rate was not simply habituation but was, rather, an active process consequent to the experimental conditions. An examination of pre-CS levels within days indicated that rate increased over trials in the avoidance group ($p < .001$) and remained constant in controls. Further, the abrupt drop in pre-CS rate of the avoidance group at the start of extinction, when the consequences of nonresponse were suddenly changed, supports the notion that "resting" heart rate levels were reduced as a function of the experimental situation. Stern & Word (1962) reported that intertrial heart rates showed a continuous downward trend in avoidance conditioning of the rat, and they decided for this reason to analyze only change scores. The present results indicate that a major change in intertrial rate was the chief factor in the growth of the CS minus pre-CS change score in the avoidance group; i.e., the rate during presentation of the CS remained relatively constant throughout conditioning but, since the pre-CS level decreased over sessions, the change scores had to increase.

The avoidance animals differed from their control partners in both magnitude and slope of the conditioned cardiac response during acquisition and extinction. If it were assumed that, since the parameters of CS and US stimulation were identical for both animals of a pair, the yoked control's response was a measure of the emotional response to the CS as a function of conditioning, one would conclude that, as the avoidance behavior was acquired, the emotional response to the CS diminished. Such an interpretation would be in accord with the notions of Solomon & Wynne (1954) concerning "conservation of anxiety." The conditioned heart rate response of avoidance animals, however, increased over acquisition trials. Part of this increase in heart rate can be attributed to a direct effect on the cardiovascular system of the motor response of hurdle-jumping. It is clear from Fig. 2 that there was a positive relationship between conditioned cardiac and CAR curves for the avoidance group.

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Notes

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