Bulletin of the Psychonomic Society
1976, Vol. 7 (3), 292-294

Gradual increase vs. constant-intensity shock during rabbit heart rate conditioning

ARTHUR L. YEHLE and HSIU-YING LAI
Memphis State University, Memphis, Tennessee 38152

In an attempt to delineate some aspects of heart rate conditioning anomolies, 40 New Zealand albino rabbits were subjects in a classical discrimination conditioning study employing a pulsed tone for a conditioned stimulus and an electric shock as an unconditioned stimulus. A 2 by 2 factorial design used two different shock intensities of 6 and 14 mA and two different conditions of shock administration, gradual increase of intensity, and constant intensity. The conditioned heart rate response was measured by comparing the heart rate for 10 beats preceding the tone onset with the rate for 10 beats following the tone onset during interpolated test trials. No differences among the four groups were found in discrimination ability, nor were there any differences between the 6- and 14-mA groups for either shock administration condition. Both constant shock groups, however, showed significantly larger deceleratory heart rate responding during the first several days of training, but this responding decreased rapidly to the same relatively stable level of responding exhibited by the gradual increase groups.

Harris and Brady (1974) have pointed out that the results of cardiac conditioning studies using electric shock as the unconditioned stimulus (UCS) are remarkable in their lack of consistency even when paradigms are similar and only a single species is considered. They state, for example, "both increases and decreases have been reported within the same species by investigators using essentially the same procedures and even the same animal (p. 109)." They also noted that shock intensity might partially account for the conditioned cardiac variability and a number of investigators (Meredith & Schneiderman, 1967; Yehle, Lai, & Shen, 1971) have varied this parameter and noted concomitant changes in the conditioned cardiac response.

Another consideration with respect to the use of shock as a UCS is its method of presentation, e.g., a gradual increase vs. a constant intensity. The well-known phenomena of adaptation and habituation suggest that physiological mechanisms responsible for heart rate (HR) changes during initial presentation of shock may either be joined or superseded by other mechanisms during later or repeated presentations. Graham and Clifton (1966) have suggested that both an orienting response and a defensive reflex combine to determine the resultant conditioned cardiac response and that the orienting component occurs to a weak or moderate stimulus and shows habituation over trials. Later, Katcher, Solomon, Turner, & LoLordo, Overmeir, & Roscorla (1969) indicated that while baroreceptors in the carotid sinus may be responsible for HR decreases during initial trials with a moderate to strong shock, repeated trials to the same-intensity shock showed (in certain instances) no blood-pressure elevation and hence no baroreceptor involvement even though HR decrease still continued to occur. The implication is that cardiac conditioning variability may also be a function of the nature of shock administration during early trials as well as a function of shock intensity.

The present study attempted to further delineate conditioned cardiac variability by examining the effect of both shock intensity and method of shock presentation.

METHOD

Subjects

The subjects were 40 New Zealand albino rabbits, approximately 14 weeks old and weighing approximately .5 kg. Each subject was caged individually and had free access to food and water.

Procedure

During training subjects were restrained in a Plexiglas box which was placed in a dark ventilated sound-attenuated chamber. Two stainless steel saftey pins were inserted into the skin of each subject to record the HR.

The conditioned stimuli (CS) were 700-Hz tone pips of either two or eight pulses per second presented to the subject through a 6-in. speaker located 4 in. above the subject. The UCS, a .3-sec duration constant current electric shock, was administered through stainless steel sutures inserted into the skin of both the upper and lower eyelids of the subject's right eye. The CS duration was 2.3 sec and the offset of the CS was coincident with the offset of the UCS on CS+ trials. The intertrial interval was 69 sec.

For half the subjects, the CS+ was composed of 700-Hz tone pips at the rate of eight per second with a duration of 2 msec, and the CS- was similar but with a rate of two per second and a duration of 4 msec. These conditions were reversed for the other half of the subjects.

The subjects were randomly assigned to one of four groups of 10 subjects each. A 2 by 2 factorial design used two different shock intensities of 6 mA and 14 mA and two different conditions of shock intensity control. In one of these two conditions, the shock intensity was constant, i.e., it was set at either 6 mA or 14 mA and maintained at that value for 10 days of classical discrimination conditioning. In the second condition, the shock intensity was gradually increased from 2 mA to either 6 mA or 14 mA over a

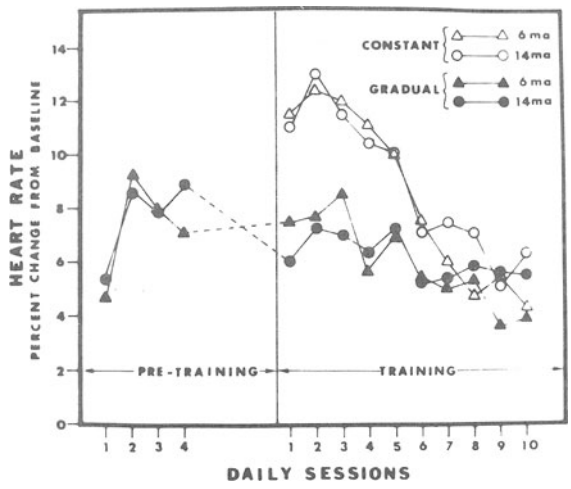

Figure 1. Conditioned heart rate responses (deceleratory) to the CS+ for all four groups.

period of days in the following manner. If a subject's mean HR response for a given day exceeded a 9% conditioned response (CR), then the shock intensity was not changed for the following day's training. However, if a subject's HR CR fell below 9% on a given day, the shock intensity for the following day's training was raised 1 mA. When the intensity reached either 6 mA or 14 mA (depending on the group), it was then maintained at that level for an additional 10 days of training.

During each daily session, subjects received 24 trials with the CS+ and 24 trials with the CS– randomly presented with the restriction of no more than two similar trials in succession. Trials 11 and 12, 23 and 24, 35 and 36, and 47 and 48 were designated as test trials (no UCS) and used to assess HR responding to the CS+ and the CS– by measuring the distance between 10 successive heart beats prior to CS onset and comparing this with the measurement of 10 successive heart beats immediately following CS onset. A percent change from baseline was then calculated and used as a measure of HR CR.

RESULTS AND DISCUSSION

The HR responses of each of the four groups indicated discriminatory responding from the 1st day of conditioning to the conclusion of the study, but no differences among the four groups occurred in discrimination ability, so only the results of the HR responses to the CS+ are presented.

Three points are worthy of note in Figure 1 which portrays the conditioned HR response (deceleratory) for the various groups. First is the sharp increase in responding on the 2nd day of conditioning (2nd day of pretraining for the gradual groups, 2nd day of training for the constant groups). This effect is an artifact of response measurement and due to the change in latency of the HR response. The recruitment of the HR response has been found to occur within 10 successive heart beats following CS onset for studies of this nature, except for the initial day of conditioning where it occurs during the second 10 beats (between 10 and 20). In other words, by the 2nd day of training (or pretraining), the rabbits' HR returns to within 1 or 2% of the pre-CS baseline during the 10 beats following CS onset. A more precise analysis (beat by beat during recruitment) indicates near equal magnitudes of conditioned responding during the first 2 days.

Secondly, but of considerably more importance, is the lack of significance in HR responding between the 6- and 14-mA groups for either the constant or gradual administration condition. Schneiderman, VanDercar, Yehle, Manning, Golden, and Schneiderman (1969) have reported that larger unconditioned deceleratory responses were elicited to 20 mA than to 3 mA. The measured response in this study, however, is the result of the combination of both acceleratory and deceleratory impulses to the heart. Therefore a larger deceleratory portion of the response in the 14-mA groups may have been offset by a greater acceleratory component known to be the result of gross body struggling movements (Obrist, Wood, & Perez-Reyes, 1965). Evidence for increased bodily activity was noticed by the frequent presence of EMG activity in the HR record for the 14-mA groups. In addition, the range of shock intensities used in this study might not have been great enough to show a marked distinction between the two groups.

Finally and of most importance is the significant difference between the constant and the gradual groups during the initial days of training. Due to the nature of shock administration, the animals in the gradual groups received differing amounts of pretraining, so only the data from the first four sessions of pretraining is presented. The day on which the shock intensity reached either 6 or 14 mA (depending on the group) for each animal was considered the 1st day of training and so portrayed for comparison with the constant groups. The large HR deceleration during the initial days of training for the constant groups reflects a compensatory response to a sympathetically induced elevation in blood pressure (Yehle, Dauth, & Schneiderman, 1967). The rapid decrease of the HR response over the next few days is probably due to both the habituation of the orienting component mentioned previously and the slower conditioning of gross bodily movements, causing the accelerative component of the HR response to subtract from the larger decelerative component (Obrist et al., 1965). In contrast, the gradual groups which began pretraining with a relatively mild shock (2 mA) exhibit less of a compensatory response and effect skeletal-motor conditioning during pretraining as shock intensity is increasing. Thus, when training commences for the gradual groups, movement conditioning is complete and the net HR response shows little change. Dogs which were administered shock of low intensity that gradually increased over trials responded in a similar manner (Church, LoLordo, Overmeir, Solomon, & Turner, 1966) and support these findings with rabbits. Church et al.

(1966) suggest that the gradual increase of shock reduces the "subjective severity" of the later more intense shock.

The technique of gradually increasing shock intensity used in this study for the gradual groups, has its counterpart in the systematic desensitization type of therapy and thus may have important research implications.

REFERENCES

CHURCH, M., LOLORDO, V., OVERMEIR, J. B., SOLOMON, R. L., & TURNER, L. H. Cardiac responses to shock in curarized dog: Effects of shock intensity and duration, warning signal and prior experience with shock. *Journal of Comparative and Physiological Psychology*, 1966, **62**, 1-7.

GRAHAM, F. K., & CLIFTON, R. K. Heart rxte change as a component of the orienting response. *Psychological Bulletin*, 1966, **65**, 305-320.

HARRIS, A. H., & BRADY, J. V. Animal learning—visceral and autonomic conditioning. *Annual Review of Psychology*, 1974, **25**, 107-133.

KATCHER, A. H., SOLOMON, R. L., TURNER, L. H., LOLORDO, V., OVERMEIR, J. B., & RESCORLA, R. A. Heart rate and blood pressure response to signaled and unsignaled shocks: Effects of cardiac sympathectomy. *Journal of Comparative and Physiological Psychology*, 1969, **68**, 163-174.

MEREDITH, A. L., & SCHNEIDERMAN, N. Heart rate and nictitating membrane classical discrimination conditioning in rabbits under delay versus trace procedures. *Psychonomic Sciece*, 1967, **9**, 139-140.

OBRIST, P. A., WOOD, D. M., & PEREZ-REYES, M. Heart-rate during conditioning in humans: Effects of UCS intensity, vagal blockade, and adrenergic block of vasomotor activity. *Journal of Experimental Psychology*, 1965, **70**, 32-42.

SCHNEIDERMAN, N., VAN DERCAR, D. H., YEHLE, A. L., MANNING, A. A., GOLDEN, T., & SCHNEIDERMAN, E. Vagal compensatory adjustment: Relationship to heart rate classical conditioning in rabbits. *Journal of Comparative and Physiological Psychology*, 1969, **68**, 175-183.

YEHLE, A. L., DAUTH, G., & SCHNEIDERMAN, N. Correlates of heart-rate classical conditioning in curarized rabbits. *Journal of Comparative and Physiological Psychology*, 1967, **64**, 98-104.

YEHLE, A. L., LAI, H., & SHEN, H. Maintenance of heart-rate responding during classical conditioning of the rabbit. *Psychological Reports*, 1971, **29**, 1341-1342.

(Received for publication December 10, 1975.)

ERRATUM

Whishaw, I. Q. Light aversion of normal and posterior neodecorticate rats. Bulletin of the Psychonomic Society, 1976, 7 (1), 96-98. Figure 1 on Page 97 was inadvertently omitted in printing. It is reproduced below. We apologize for the error.

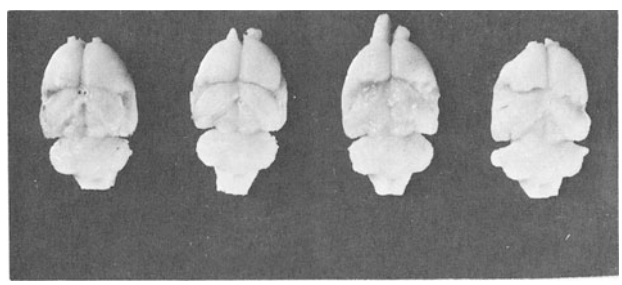

Figure 1. Representative examples of brains of posterior neodecorticate lesioned rats. Such lesions are accompanied by complete degeneration of the dorsal part of the lateral geniculate body (see Bland & Cooper, 1970).