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A Preliminary Investigation of the Relationship Between GSR, Heart Rate Change and Eyelid Conditioning[1]

By W. N. RUNQUIST and L. E. ROSS

Recent studies of classical defense conditioning at the Iowa laboratory have been concerned largely with the relation of drive level (*D*) to level of performance in conditioning. According to the theoretical formulation offered of the results of these studies, the associative factor, *H*, and drive factor, *D*, combine multiplicatively to determine reaction potential, *E*, which in turn determines the strength of the response, i. e., $R = f(E) = f(H) \times f(D)$. It has further been assumed that *D* is a function of (a) the intensity of the UCS, and (b) the score on the Manifest Anxiety (A) scale (8). The mechanism underlying these assumptions presumably involves the emotional response (r_e) to the noxious stimulation of the UCS. This emotional response is assumed to be relatively persistent, extending well beyond the intertrial intervals usually employed in conditioning experiments. Thus *D*, present at the moment of a conditioned anticipatory response, is conceived to be, in part, a function of the residual effects of the emotional reaction to the noxious stimulation of preceding trials. The higher the intensity of the UCS, the greater the magnitude of r_e and the higher the level of *D*. The use of the A scale to define *D* has assumed that the differences in A scores reflect differences in the magnitude or strength of the emotional response to the same UCS by these *S*s. That is, *S*s who make high A scores give a greater emotional response (r_e) than *S*s who make low A scores. Since it has been assumed that *D* is a function of the magnitude of r_e, these high A *S*s should exhibit a higher level of response than low A *S*s. The evidence confirming this prediction has recently been summarized by Spence and Ross (6).

It is common procedure among both psychologists and physiologists to infer the presence or absence of emotional states from certain physiological changes which presumably are a result of action of the autonomic nervous system. Among some of these changes are skin temperature, galvanic skin response, heart rate change, blood pressure change, and respiration rate.

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[1]This study, conducted under the general direction of Professor K. W. Spence, is part of a project concerned with the influence of motivation on performance in learning under contract N9 onr-93802, Project NR 154-107 between the State University of Iowa and the Office of Naval Research. Some of the *S*s were run by D. W. Stubbs.

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If r_e is defined in terms of some or all of these physiological measures, it should be possible to determine the relative emotionality of an *S* by measuring the magnitude of these responses to noxious stimulation. According to the theory outlined above, which equates *D* with the magnitude of r_e, *S*s who give relatively large physiological responses should exhibit a higher level of performance than *S*s who give relatively small responses.

The purpose of this study was to investigate the relation between level of emotional response as defined by the magnitude of physiological changes in response to the UCS and the level of performance in eyelid conditioning. The galvanic skin response (GSR) and heart rate change were the measures used.

Method

General

The experiment was run in two sessions. On the first day each *S*'s heart rate change and GSR were measured in response to stimulation provided by an air puff to the eye. On the second day, additional measures were taken and *S*s were conditioned. The second session varied from two to 24 days following the first session.

Subjects

The *S*s were 60 introductory psychology students. Twelve *S*s were eliminated due to apparatus failures which prevented obtaining some physiological response measures. Six additional *S*s were run but eliminated as voluntary responders (7).

Apparatus

The apparatus for recording the GSR has been described fully elsewhere (2). The electrodes consisted of two small plastic cuplike units, the bottoms of which were made of zinc. These were fastened to a hinged holder which could be clamped on to *S*'s hand. The electrodes were placed on *S*'s right palm and the back of his hand. A small piece of cellulose sponge saturated with zinc sulphate paste was placed in each unit.

The heart rate was recorded electrically through a standard EKG amplifier. Electrodes saturated with paste were placed on each of *S*'s forearms. Each pulse beat closed a relay which made a mark on a continuously moving paper tape.

The apparatus for delivering the air puff and recording eyelid responses was identical to that used in previous studies (5, 7). The duration of this air puff was 50 msec. and was controlled by means of a 110 V. AC operated solenoid valve controlled by electronic timers.

Testing Procedure, Day 1

The procedure for measuring the magnitude of the responses to the air puff was as follows: the *S* was seated in a dental chair in a semi-soundproof darkened room with all electrodes attached and the headset for delivering the air puff in place. Ten minutes were allowed for *S*'s heart rate and base-level skin resistance to adapt to a steady level. Five presentations of a .6 lb. air puff at one minute intervals. were followed by five presentations of a 2.0 lb. air puff. The heart rate and skin resistance were measured continuously for 15 sec. beginning 5 sec. before the onset of the air puff. For each stimulus presentation, the base level resistance and the base level heart rate in beats per minute were recorded, as well as the maximum GSR change and the maximum change in heart rate following stimulation.

Day 2

On the second day, the same procedure was followed except that the adaptation period was shortened to five minutes and only five presentations of a .6 lb. air puff were given.

Conditioning Procedure

Immediately following the test trials on the second day, all *S*s were given 80 eyelid conditioning trials with a .6 lb. puff. The CS was the increase in brightness of a 6 cm. circular disc from .6 to 1.5 mL. The CS duration was 550 msec., with the air puff occurring 500 msec. after the onset. On the conditioning trials a verbal ready signal preceded each trial by 2, 3, or 4 sec. in prearranged order. *S*s were instructed to blink and fixate the circular disc upon presentation of the ready signal. The intertrial interval was 15, 20, or 25 seconds, also in a prearranged order. A CR was recorded whenever the record showed a deflection of 1 mm. or more in the interval 200 to 500 msec. following the onset of the CS.

Results and Discussion

Analysis of Test Data

For each of the 48 *S*s there were available ten GSR responses on day 1 and five GSR responses on day 2. A heart rate response measure was not available for each test trial due to recording difficulties. The measure of heart rate response was taken as the mean algebraic change in rate following the air puff over those trials in which a measure was possible. For some *S*s, this was only two or three trials. For 17 *S*s, for whom heart rate measures were available for both days, the larger of the two mean changes was used. Correlation between day 1 and day 2 measures was .34. Since the correlation between mean GSR in log micromhos on day 1 and mean GSR on day 2 was -.05, both measures were used. Thus the measure of emotional responsiveness was made up of a single measure of heart rate change and two measures of GSR.

There are certain measurement problems involved in the use of raw scores of these measures. These problems stem largely from the high correlations between base level and response level usually obtained in measures of this type.[2] A thorough discussion of these problems is given by Haggard (1), and Lacey (4). For the purposes of this experiment, the solution proposed by Lacey has been adopted.

The problem and its solution may be briefly stated as follows: What is desired is to determine the magnitude of response in such a way that *S*s may be rank-ordered according to their responsiveness independent of the base level. The ideal solution would be to have extensive norms for all response measures and stimuli. These norms would give frequency distributions of the changes at varying base levels. Thus a given *S*'s response could be referred to this distribution of responses obtained for all *S*'s with that particular base level, and the magnitude of his response could be expressed as a relative deviate or *z*-score from the mean of that particular group. These normative data are lacking and indeed may even be unobtainable.

An approximation to this ideal may be made by means of the statistical techniques of regression analysis. This method leads to the following transformation:

AL (autonomic lability) $= 50 + 10 \dfrac{(Y_z - X_{z2}R_{xy}),}{1 - r_{xy}\ ^1\!/\!_2}$ where X_z and Y_z are the individuals base level and response level expressed in z scores, and r_{xy} is the correlation between base level and response level. The constants provide a distribution of scores with mean of 50 and standard deviation of 10. AL, then, is a deviation score based on the estimated mean and standard deviation at a particular base level. That is, a score of 50 represents an *S* whose response is exactly at the estimated mean of *S*s whose base level is the same as his. A thorough discussion of the rationale behind this formula is given by Lacey (4).

In the present data, AL scores for the heart rate measure, day 1 GSR and day 2 GSR were determined by the above formula. The correlations between base level and response level were .97, .99, and .85 for heart rate, day 1 GSR and day 2 GSR respectively. The distributions of the AL scores are all approximately normal. In general, GSR responses on day 2 were smaller, and there was less variability between *S*'s. A combined AL score for each *S* was then

[2]The correlation in this study between base level resistance and ohms change were .54 on day 1 and .26 on day 2. Both were significant at .01 level. The correlation between based heart rate and heart rate acceleration, however, was only .10.

obtained by adding the AL scores for the three response measures. A high AL score presumably indicates greater intensity of emotional response.

Conditioning

The *S*s were divided into three groups corresponding to the top, middle, and bottom thirds of the distribution of AL scores. Curves of the acquisition of the CR based on the percentage of responses occurring in blocks of ten trials for the three groups are presented in Figure 1. As may be seen, the high AL *S*'s condition to a higher level than the low AL *S*'s. The medium AL *S*'s fall in between these two extremes for most of the course of conditioning. Statistical

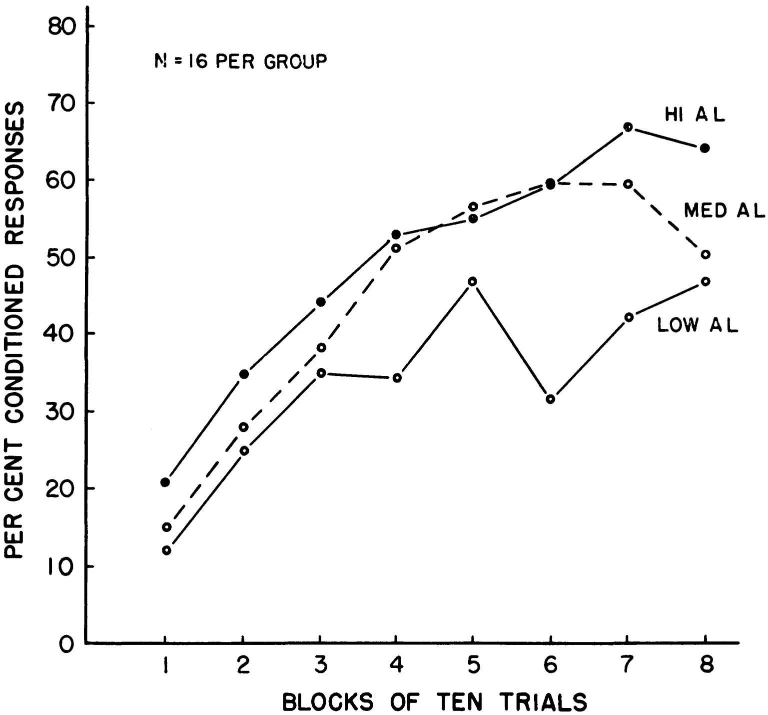

Fig. 1. Per cent conditioned responses as a function of blocks of ten trials, for the levels of emotional responsiveness.

evaluation was made on the number of CR's on trials 51-80 by means of Jonkheere's test for ordered alternatives (3). This statistic takes advantage of the fact that the theory predicts a specific order for the three groups. The z obtained was 1.61 which is significant at the .05 level. A Mann-Whitney test comparing high and low groups gave a z of 1.88 which was significant at the .02 level.

The predictive value of each of the three separate AL measures was assessed by grouping *S*s into high, middle, and low AL based on each measure separately. The mean number of CR's is plotted in Figure 2 as a function of AL category on the three measures separately. These curves clearly show that AL level based on each measure separately predicts level of conditioning fairly well, with heart rate change providing the least differentiation between conditioning levels.[3]

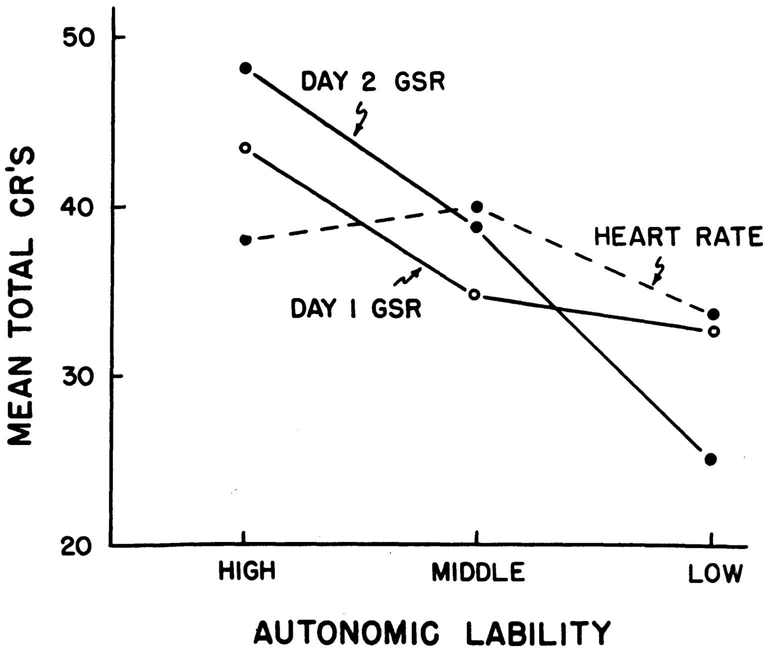

Fig. 2. Mean total conditioned responses as a function of autonomic lability for each of three different physiological measures.

The results generally are in accord with the theoretical formulations which assume that drive level (D) is a function of the intensity of the emotional response (r_e) of the S to the UCS.

It is encouraging that results as clearly supportive were obtained despite the apparatus difficulties which prevented obtaining measures of emotionality on every test trial. Replication under better conditions of measurement is desirable, however, before these results are

[3]It is interesting to note that heart rate acceleration when not transformed showed a better relation to conditioning. This was not true with the GSR measures. Although both of these measures did show the predicted relation to conditioning, the differences between high, middle, and low responders was quite small, and there were a few reversals. Although the use of transformations on physiological measures is quite common, most of these are quite arbitrary. That Lacey's transformation does not change the raw scores much is indicated by the correlation of .84 between ohms change and AL. Whether the transformation of these measures is useful is a matter for further research.

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interpreted as unequivocal support for the use of these physiological responses in defining drive level.

Summary

To test a hypothesis relating drive level in conditioning to emotional responsiveness 48 *S*s' GSR and heart rate acceleration were measured to air puff stimulation. Measures were made on two separate days. On the second day all *S*s were given 80 eyelid conditioning trials.

When the *S*s were divided into high, medium, and low emotionally responsive groups on the basis of a score derived from the GSR and heart rate measures, the high emotional responders showed the highest level of performance in conditioning, and the low responders the lowest, with the medium responders falling between the two extremes, thus supporting the hypothesis.

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