Changes in task performance as a result of stress
by Scott Wilson Brown

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Psychology
Montana State University

Abstract:
An experiment was conducted investigating changes in the task performance of rats when preceded by electric shock. The study involved five stress groups: a control; an approach-avoidance gradual group, in which the shock was administered when the subject pressed the bar in a Skinner box, on a gradually increasing basis; an approach-avoidance sudden group, in which the subject received a high level of shock for each bar press; a non-contingent gradual group, in which the shock was gradually increased and was not contingent upon a response; a non-contingent sudden group, which received the shock at a high level, not contingent upon a response. The subjects were trained in bar pressing in a Skinner box, running in an alley and learning a discrimination in a Y-maze. The shock was administered in the Skinner box, and the subjects were subsequently tested in the alley and the Y-maze. Measures of running speeds were recorded for the alley and the Y-maze.

The results indicated that the non-contingent gradual group adapted to the stress as well or better than the approach-avoidance gradual group which previously had been investigated by Miller (1960) and Karsh (1962). It was also found that there was a significant difference in running speed in the alley between the approach-avoidance gradual group and the non-contingent gradual group. The findings of this experiment were interpreted in terms of previous physiological research and learning theories.

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ABSTRACT

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INTRODUCTION

Stress is a very general term which has come to denote a condition of physical and/or psychological tension which causes changes in the autonomic nervous system. Stress may come in many forms, in this study it will be represented by electric shock. In recent years, studies of stress have been conducted along two major lines, physiological studies of stress reactions by the body and psychological attempts to train subjects to resist stress. One major contribution in the field of physiological reactions to stress has been made by Selye (1956), who developed a descriptive system of reactions to stress which he called the General Adaptation Syndrome. These adjustments to stress are divided into three successive stages; (1) the alarm reaction, in which adaptation is not yet acquired and the organism is startled by the stress, (2) the stage of resistance, in which adaptation is optimal with specific hormones secreted aiding in the resistance, (3) the stage of exhaustion, in which the organism is completely exhausted and is no longer capable of adapting to the stress. The descriptive analysis of the General Adaptation Syndrome is based upon Selye's (1952) examinations of rats under stress. He found some of the characteristic symptoms of stress to be enlarged and discolored adrenals, involuted thymus and lymph nodes, and an

ulcerated stomach wall.

Levine (1971) qualified Selye's (1952, 1956) work by defining the specific series of events which take place on the physiological level during stress adaptation. He found that a signal is received by the hypothalmus from the central nervous system, indicating the presence of stress. The hypothalmus then secretes a corticotropin-releasing factor which stimulates the pituitary to secrete the hormone ACTH. The ACTH then stimulates the cortex of the adrenal gland to increase its synthesis and secretions of hormones. The key hormones secreted are glucocorticoids. In the human, the glucocortinoid is primarily hydrocortisone, while in the rat it is corticosterone. With the physiological studies of stress well documented by Selye (1952 and 1956) and Levine (1971), a basis for understanding the changes in the body resulting from stress may be understood.

Miller (1960) conducted a series of experiments concerning training programs in which rats learn to resist stress. Miller trained rats to run down an alley to receive a food pellet and an electric shock at the goal. The first group, which Miller called the gradual condition, received an electric shock of 125 volts at the goal for five trials on the first day, and the voltage was increased in 15% steps on each successive day until it reached 335 volts on the

fifteenth day. The second group, called the sudden condition, received five practice trials a day with no shock at the goal during the fifteen day period that the gradual group was receiving the gradually increasing shock. Once the gradual group reached the 335 volt level, the sudden group also received the same level of shock intensity at the goal. Both groups then received five trials a day at the 335 volt level for 20 days.

Miller (1960) found that after just one shock at the goal, the running speed of the sudden group increased dramatically. The running speed of the gradual group on the other hand did not change as dramatically and stayed at a faster speed than the sudden group. Miller's findings indicated that through the training program of gradually increasing shock, an organism is capable of adapting to stress much better than one without the training. Further experimentation by Miller (1960), testing to discover the effects of the gradual introduction to stress when presented outside the test condition, indicated that training to resist stress through the program of gradually increasing shock was not effective in reducing the change in running speed when introduced to the alley task. Miller, therefore, concluded that the training to resist stress was specific to the training situation.

Karsh (1962) conducted experiments similar to those of Miller (1960), and found that the running speed after a change in the shock intensity was determined by two factors, the present and the previous shock experiences. An analysis of Karsh's findings indicated that the initial experience with the electric shock was the more critical factor. He concluded that the changes in shock intensity, regardless of the direction, produced gradual "incomplete" changes in running speed. These incomplete changes in the running speed were in the form of highly variable running speeds without trend or pattern in the overall direction or magnitude of change. These changes were labeled "incomplete" because they varied in both directions and did not form a standard pattern.

The physiological nature of stress has been established through the work of Selye (1952, 1956) and Levine (1971). Adaptation training of Miller (1960) and Karsh (1962) has been found to reduce disruptions in behavior in the stressful environment. The research along these lines has been relatively separate in postulating the effects of stress. The present study is an attempt to intergrate these two lines of research on the issue of the effects of a stressful environment on behavior and the possible changes in behavior in subsequent tasks. The General Adaptation

Syndrome has been found to involve the secretion of hormones and changes in the physiological make-up of certain organs in the body (Selye 1952, 1956 and Levine 1971). Possibly the same physiological changes which aid in adapting to stress may influence performance on a series of tasks when these tasks are preceded by a stressful environment.

The present study had two main objectives. The first attempted to discover whether there are any changes in task performance as a result of the presence of stress in another situation. The second was an attempt to determine the effectiveness of a training program which was based upon a gradually increasing shock not contingent upon a response by the subject, the non-contingent gradual group. Through the use of three entirely different tasks, bar press rate in a Skinner box, running speed in an alley, and running speed and error rate in a Y-maze involving a discrimination, changes in behavior and the processes involved in each were examined. These three different tasks were chosen because each requires the use of a different type of response. The bar press task in the Skinner box requires that the subject press the bar and then move to the food cup to obtain a reward. The running speed in the alley requires motor coordination to obtain the food pellets in the goal box. The running in the Y-maze, like that of the alley, involves

motor coordination, but it also involves a decision process as to which door to choose. Therefore, by using these three tasks, the processes of each may be examined. The effects of a stressful environment produced by electric shock paired with a food reward in the Skinner box, were examined as it affected the behavior in each of the other tasks. Five different groups--a control, two sudden stress groups, and two gradual stress groups--were tested in the three tasks consecutively every day for 20 days. At the end of the 20 days of testing, the electric shock was terminated and the testing in the three tasks continued for another 20 days. Through this procedure, the changes in the performance in the three tasks were examined under the conditions of stress and the subsequent non-stress situation.

Of the five groups used in this experiment, two were of the same type used by both Miller (1960) and Karsh (1962)--an approach-avoidance gradual group and an approach-avoidance sudden group. By using approach-avoidance groups, two types of stress were applied, the physical stress of the electric shock and the psychological stress of a decision. The psychological stress of a decision can have a great effect as shown in earlier experiments by Miller (1951) with approach-avoidance anxiety and Brady (1958)

with the "executive monkey" experiment, in which the "executive monkey" died from stomach ulcers as a result of making constant decisions. Since one goal of the present study was to clarify conditions under which organisms can adapt to stress, a second type of training was developed, the non-contingent gradual group. The non-contingent groups received the same electric shocks as the approach-avoidance groups but they were not administered contingent upon a response as in the approach-avoidance groups. Through the use of the non-contingent groups, the stress of a decision in an approach-avoidance conflict was eliminated, providing groups which were identical to the approach-avoidance groups except for the criterion used in administering the shock. Thus, a non-contingent gradual group and a non-contingent sudden group, comprised two other groups. The fifth group, a control condition, did not receive any electric shocks. The gradual groups were believed to enter the General Adaptation Syndrome and adapt to the stress through the aid of hormonal changes previously described. These hormonal changes were expected to cause highly variable response rates in the gradual groups. The sudden groups, which as a result of the sudden introduction of the electric shock passes quickly through the stages of alarm and resistance into the stage of exhaustion. Once in the stage

of exhaustion, hormonal changes become minimal and, therefore, response rates should be less effected than those in the gradual groups.

Through the use of these five groups and the general procedure of measuring the performance changes in each task, the behavioral changes resulting from a stressful environment were studied under each condition. Through the use of the Skinner box as the stress-inducing situation, a different type of response criterion, bar pressing, was examined to determine the effectiveness of approach-avoidance groups and the non-contingent groups in resisting stress in another type of situation. The non-contingent gradual group provided an alternative type of training which may be as effective in adapting to stress as the approach-avoidance gradual group, since as Brady (1958) has demonstrated the effects of a decision in a stressful situation are of a great magnitude. Changes in performance or differences between groups were interpreted by combining the two lines of research, physiological and learning theories, which went beyond the limitations of each and created a mode of understanding the highly variable response rates resulting from previous exposure to a stressful environment.

METHOD

Subjects.

Ten Sprague-Dawley rats were housed individually and maintained at approximately 80% of their free-feeding body weight. Each subject was approximately 150 days old at the start of the experiment.

Apparatus.

A BRS/LVE shock generator/scrambler was calibrated in milliampers ranging from 0.0 ma to 10.0 ma, connected to the grid floor of a standard Skinner box. It administered an electric shock which was scrambled through the grid of the Skinner box floor to the rat. A Rustrak recorder was connected to the Skinner box, providing a permanent record of the time of each bar press for each subject on each day. A Hunter timer and a relay were connected between the Skinner box and the shock generator/scrambler, and the duration of the shock was set at 0.1 second. A standard power supply set at 28 volts was used to operate this equipment.

The alley (see Figure A1) which was constructed of plywood, was 20.3 cm high sides, 20.3 cm wide and 2.434 m long. The floor and the top were constructed of 1/4 inch wire mesh. The sides of the alley were painted flat blue. A fast-action, side-swinging door was placed 17.8 cm from the front of the alley. A microswitch behind the door activated

a Hunter Klockounter upon the opening of the door by a switch outside the alley. A photo-electric cell was mounted 12.7 cm from the back of the alley. The interruption of the photo-electric beam by the rat stopped the Hunter Klockounter. The running distance from the door to the photo-cell was therefore 2.10 m. In the last 12.7 cm of the alley, the goal box, a food cup was placed containing two food pellets for each run.

The Y-maze (see Figure A2) was constructed of plywood, with 20.3 cm high sides and 20.3 cm wide. The stem of the Y was 1.35 m, as measured along the outside walls to the focal point in the Y. The arms of the Y were set at a 45^{o} angle to the stem and were 1.04 m each. The sides were painted flat brown. The start box was 17.8 cm long, as measured from the inside back wall. It was opened by a fast-action, side-swinging door, the same type as used in the alley. Behind the door was a microswitch which was connected so that the opening of the door activated the Hunter Klockounter. In each of the stems of the Y was mounted a photo-electric cell, 12.7 cm from the back wall, which stopped the Hunter Klockounter when interrupted. The last 12.7 cm of each arm was designated as a goal box and contained a food cup. A hanging door, which opened when pressure was applied to the bottom, was located 61.0 cm

from each of the photo-electric cells. The two doors were constructed of a light weight cardboard. One was covered with white construction paper, the other with black. Two blocks were placed on the side walls of each stem of the Y next to the hanging doors in such a manner that the doors would allow the rat to enter the goal box area, but not leave it. The running distance from the fast-action door to either one of the photo-electric cells was 2.10 m.

Running speed between the fast-action doors of the start boxes and the photo-electric beams was measured in the alley and the Y-maze.

Procedure.

Training--Each subject received training in the Skinner box, alley, and the Y-maze until they reached a steady rate of responding in each of the three tasks. The subjects were trained in a Skinner box to press the lever and receive a standardized precision food pellet. The training in the alley consisted of successively increasing the running distance until it reached 2.10 m from the door of the start box to the photo-electric cell. In the Y-maze, the subjects were trained to run for a reward to the black door. Once all the subjects had chosen the correct door on five successive trials, the training in the Y-maze was discontinued. Each subject received three practice trials of the entire

series of three tasks, one on each of three consecutive days. On the third day of practice trials, the subjects were randomly assigned to the experimental groups.

Testing--Each subject was placed in the Skinner box for a five minute session. During this session, the stress, in the form of electric shock, was administered to the rat according to the stress group of which he was a member. The Rustrak recorder provided a permanent record of the time at which the subject emitted a bar press. Food reinforcement was delivered on a continous schedule.

Once the five minute Skinner box session was completed, the subject was removed from the apparatus and placed in a cage with a water bottle for a five minute time-out period.

The subject was then put in the start box of the alley and given three trials with a one minute inter-trial interval in a cage with a water bottle. The door of the start box was opened when the subject was facing the door with his nose less than 1/2 inch away. The running speed was recorded for each of the trials in the alley.

After the last trial in the alley and the one minute inter-trial session had been completed, the subject was given three trials in the Y-maze with an inter-trial interval of one minute. A pattern for changing the hinged black and white doors was randomly selected for each day. The

pattern remained constant for all subjects for that day. Choosing the black door was always rewarded with two standard size food pellets, the size used in the Skinner box. Choosing the white door was never rewarded. The same criterion was used for the opening of the fast-action door in the Y-maze as in the alley. Both running speed and errors were recorded for each trial of each day. When the third trial was completed in the Y-maze, the subject was returned to the home cage, and the experimental session was concluded for that subject for that day.

Design--The Control (C) group did not receive any electric shocks.

The Approach-Avoidance Gradual (AAG) group received an electric shock for each bar press in the Skinner box. The shock was increased gradually in increments of 0.5 ma every other day. The first shock was 0.5 ma, and the level reached 5.0 ma at the end of the gradually increasing steps. The subjects received the 5.0 ma shock for two days once reaching this level of intensity.

The Approach-Avoidance Sudden (AAS) group received the 5.0 ma intensity of shock for the 20 days that the AAG group was receiving the gradually increasing shocks.

The Non-Contingent Gradual (NCG) group received a shock at the same point of time in the Skinner box session that

the AAG group had pressed the bar and received a shock. Thus, the number and the time of the shocks received by the AAG group and the NCG group were equivalent but the NCG group did not receive the shocks contingent upon bar pressing behavior. One subject in the AAG group was yoked with one subject in the NCG group for the entire experiment. The shock intensity of the NCG group increased in the same manner as the AAG group.

The Non-Contingent Sudden (NCS) group followed a similar procedure as the NCG group, receiving a shock at the same point of time in the Skinner box session as the AAS group but not contingent upon bar pressing behavior. The shock intensity that the NCS group received was of the same intensity as that of the AAS group.

Beginning on the twenty-first day, the subjects in all the groups no longer received any shock in the Skinner box and the procedure of testing in the three tasks was continued for another 20 days. Upon completion of the testing of all of the subjects after 20 days of no electric shock, the experiment was terminated.

In order to compare the scores of the three tasks together, they were converted to a large Z score for each measure, providing a relative score as compared with the other groups for each task. The Skinner box session was divided

into two 2 1/2 minute sessions with a bar press score for each. The third trials in the alley and the Y-maze was dropped. Through this process, the 3-way analysis of variance nested model with measurement replication was used.

RESULTS

Days 1 - 20.

The ANOVA conducted for the days 1 - 20 yielded significant results in the Stress Group x Task interaction, $P < 0.01$ (see Table 1). The only interaction of interest in this experiment was the group x task. The F value for the task source in the ANOVA was approximately zero because of the use of the Z score conversion. Figure 1 provides a graphic illustration of the Stress Group x Task interaction in mean Z scores, indicating that the relative performance of each group varied according to the task and was not constant. (For the raw scores and the converted Z scores see Tables A1 and A2).

The bar press performance for the AAG group decreased once the shock intensity reached 3.0 ma., while the performance of the NCG group remained relatively constant throughout the first twenty days. Figure 2 provides an illustration of the changes in the bar press rate on a daily basis, and a comparison of the rate to the other groups. A daily plot of the running speeds of the experimental groups for days 1 - 20 are illustrated in Figures 3 and 4. Figures 5 and 6 are plots of the running speeds in the Y-maze for each of the stress groups. These figures illustrate the changes in running speeds on a logarithmic scale in order to plot

ANOVA Table for Days 1 - 20.

Source	SS	DF	MS	F-ratio	P value
indiv/group	1143.9603	5	228.7921	_____	
group	1578.5969	4	394.6492	1.7249	
task	0.0038	2	0.0019	0.0000	
ind/task x group	484.5796	10	48.4580	1.7739	
group x task	1982.5908	8	247.8239	5.1142	$P < 0.01$
measure error	819.5039	30	27.3168		
totals	6009.2353	59			

TABLE 1