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THE EFFECTS OF COGNITIVE APPRAISAL OF STRESS ON HEART RATE AND TASK PERFORMANCE

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I. Introduction.

In aviation occupations, performance impairment under stress conditions is particularly undesirable. However, it is known that individuals differ widely in stress susceptibility.[3] Some individuals exposed to a given stress situation will show performance impairment, some may improve in performance, and others show no apparent change.[7] Previous attempts to identify, through the use of conventional anxiety scales, those individuals who may show performance impairment to a particular stress condition have generally not been too successful.[1] Within the past few years, increasing emphasis in stress research is being placed on the more direct approach of determining an individual's attitude toward a specific stress situation, under the assumption that attitudes should be significant determinants of behavioral and physiological response to the stressor.[5]

In adopting the position that cognitive appraisal of threat is a factor of major importance in accounting for individual differences in stress susceptibility, Hodges and Spielberger[2] recently hypothesized that in a given stress situation, such as threat of shock, subjects who had expressed a high fear of shock would differ from low fear of shock subjects in their over-all response to the stressor. Their general findings were that subjects classified as having high fear of shock on the basis of a questionnaire item administered several months prior to the experiment gave significantly greater heart rate increase to threat of shock than subjects classified as low fear of shock. Subjects were not aware prior to the actual administration of threat that the experiment involved any shock or threat of shock. In addition the study found no difference in the heart rate response of high and low anxious subjects to threat of shock when subjects were separated on the basis of scores on the Taylor Manifest Anxiety Scale.[11]

The present study was designed to replicate the essential findings of Hodges and Spielberger and hopefully also to relate performance change under stress to individual differences in cognitive appraisal. It was predicted that (a) subjects expressing a high fear of shock would reveal greater heart rate acceleration to threat of shock than low fear of shock subjects and (b) under threat of shock, high fear of shock subjects would demonstrate greater performance impairment on a motor (pursuit rotor) task than low fear of shock subjects. A subsidiary aspect of the study explored the question of control vs. lack of control as a factor influencing the magnitude of stress response.

II. Method.

Subjects. The subjects were male undergraduates obtained from introductory psychology courses at Oklahoma University. They were selected from a larger group which had been administered a questionnaire relating to a variety of potentially stressful situations approximately one month prior to the experiment. Each item was answered in terms of a five-point scale ranging from "not stressful" to "extremely stressful." The specific item used for selection was "receiving an electric shock." Subjects responding above the midpoint were classified as high fear of shock (HFS) subjects and those responding below the midpoint as low fear of shock (LFS) subjects. No information was provided any of the subjects contacted other than that they had been randomly selected to participate in a psychological experiment involving motor learning. A total of 24 HFS and 24 LFS subjects were used in the experiment.

Apparatus. The basic performance equipment consisted of a pursuit rotor (Lafayette Instrument Co.) and electric stop clock. The pursuit rotor was set to a rotational speed of 60 RPM and maintained at this speed throughout the experiment. An Applegate Model 230 stimulator served as the dummy "shock apparatus." Heart rate (HR) was obtained by means of a Gulton finger pulse transducer and recorded on a Beckman Type R Dynograph. The subject, all equipment, and the experimenter were located in the same room. The subject sat at a small table which held the pursuit rotor. A tape recorder was used to present all the instructions given to the subject.

Procedure. Upon arriving for the experiment, each subject was assigned according to a quasi random procedure to one of three conditions: Control (C); shock contingent (SC); or shock noncontingent (SNC). A total of eight subjects was assigned to each of these conditions in each (HFS and LFS) group. The subject was then taken to the experimental room and introduced to the experimenter who had no knowledge as to whether he was a HFS or LFS subject. Following the administration of several questionnaires, including the Taylor[11] Manifest Anxiety Scale (MAS), the subject was seated at a table holding the pursuit rotor and the initial instructions played. These instructions, which were the same for all subjects, explained how the task was to be performed during the initial training phase. The subject was told that the purpose of the experiment was to study the effects of generalized muscle tension on learning and that this was the reason for the finger sensor. After the instructions were finished, the pulse transducer was attached to the index finger of the subject's nonpreferred hand and the Dynograph adjusted. Fifteen training trials were then administered. Each trial was of 20 seconds duration with 20 second rest periods between trials. Total time that the stylus was in contact with the metal disk on the pursuit rotor was recorded by the experimenter at the end of each trial. HR was recorded continuously during this period and during the remainder of the experiment.

Following the completion of training, subjects in the two shock threat groups were played instructions which in essence informed them that during the next phase of the experiment they would be required to perform under pressure. The subjects assigned to the SNC condition were told they would receive an uncomfortable, but harmless electric shock at random intervals during some trial. It was emphasized that the shock was randomly programmed by the shock apparatus and that neither the subject nor the experimenter had any control over when it would occur. The subjects in the SC condition were also informed that they would receive an uncomfortable, but harmless shock. However, their instructions stated that this would only occur if their performance dropped below the average score they attained during training. They were told that the shock apparatus would be set to their average score, and that it would automatically deliver a shock whenever their performance fell below this value. Following completion of these instructions to a subject assigned to either of these two conditions, the experimenter brought out a rather impressive looking shock apparatus which had been previously hidden in a cabinet and placed it on a table next to the subject. Two EKG plate electrodes were attached to the subject's right leg and connected through a dummy cable to the shock apparatus. The apparatus was then plugged into a wall outlet and the experimenter manipulated several dials, presumably setting information into the machine. No questions were answered by the experimenter during this or any other phase of the experiment. The subjects assigned to the C condition were given reading material (a financial newsletter) during the period occupied by the shock threat instructions. All subjects were then given fifteen additional trials on the pursuit rotor.

During the post experimental inquiry, subjects in the SC condition were congratulated on having avoided the shock, while subjects in the SNC condition were questioned as to their reaction to the shock. Since they generally reported feeling little or nothing, the experimenter acted rather surprised and said that they must have been lucky. It was then explained that the shock apparatus had also been randomly programmed for various intensities of shock and they were fortunate in having received some very mild ones. Since no shocks were actually used in the experiment, this information was felt necessary to provide the subjects in the SNC condition with some explanation as to why no shocks occurred. In addition, it also served to reduce the possibility of feedback to other subjects that the experiment involved shock threat, but that no shocks were really used.

Measures. Heart rate was measured only during the 20-second inter-trial intervals and then con-

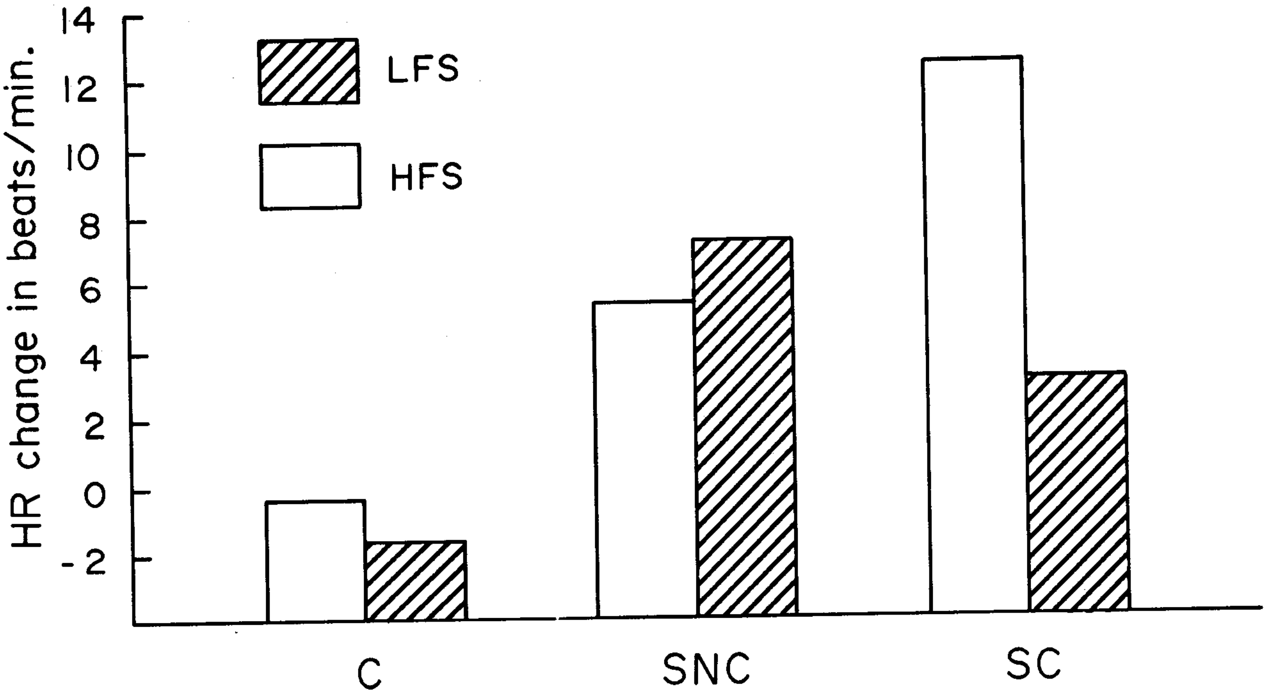

FIGURE 1. Mean heart rate change from the training period to the test period for high fear of shock (HFS) and low fear of shock (LFS) groups administered control (C), shock noncontingent (SNC), and shock contingent (SC) instructions.

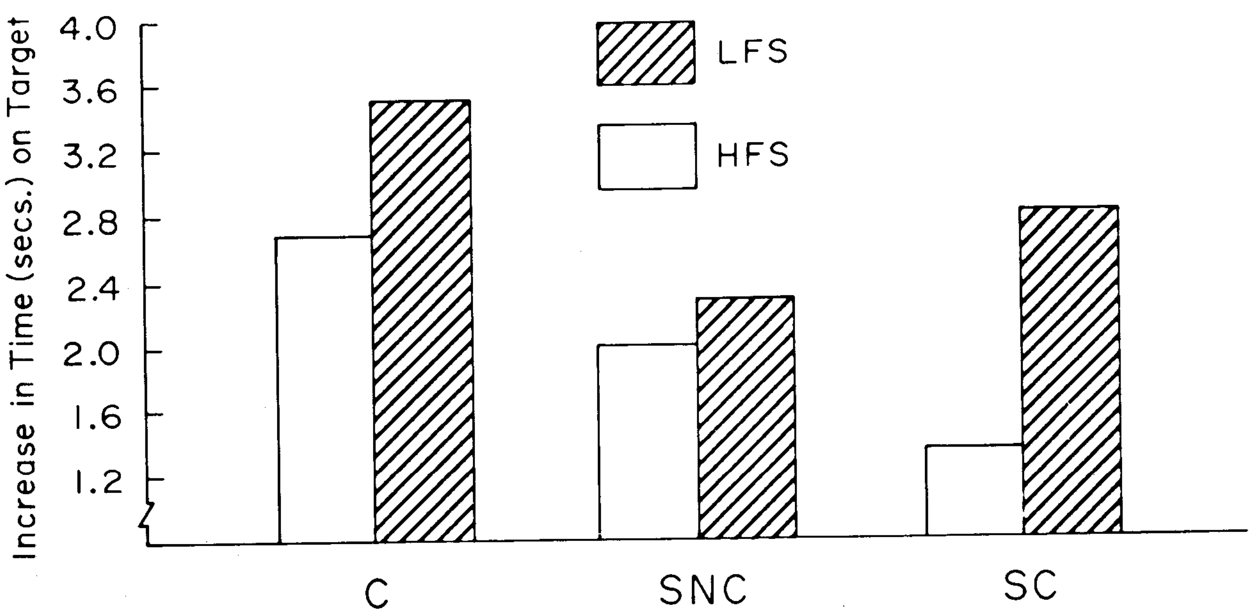

FIGURE 2. Mean performance increase from the training period to the test period for the high fear of shock (HFS) and low fear of shock (LFS) groups administered control (C), shock noncontingent (SNC) and shock contingent (SC) instructions.

verted to beats per minute. This was necessary because movement artifacts which occurred in the records of some subjects during task performance made it virtually impossible to accurately determine HR. Performance scores consisted of the total time on target in each 20-second period.

III. Results.

Mean HR during the total training period was obtained for each subject in the three LFS and HFS groups. Likewise, the mean time on target during the last five training trials was obtained for each subject in each group. Examination of the data revealed that the major portion of learning occurred during the first ten trials. Thus, the mean of the last five trials appeared to provide the most appropriate measure of performance level during the training period. Two-way analyses of variance conducted on both sets of data revealed no main effects or interactions significant at the five per cent point.

In evaluating the effects of the experimental conditions, it was decided to confine the primary analysis to the change in HR or performance occurring during the first test trial only.* Since no actual shocks were employed in the study it was expected that the effects of threat would be maximal during this period and would tend to decline without subsequent reinforcement. Consequently, the algebraic difference in HR between the 20-second period following the first test trial and the mean of the preceding training trials was obtained for each subject. For performance data the algebraic difference between each subject's score on his first test trial and the mean of his preceding five training trials was obtained.

The mean change scores for the three HFS and LFS groups are shown in Figures 1 and 2, with Figure 1 displaying the HR data and Figure 2 the performance data.

The effect of the experimental conditions on HR of the HFS and LFS groups was evaluated by a two-way analysis of variance. The summary analysis presented in Table 1 indicates that only the experimental conditions yield a significant F value.

TABLE 1. Summary Analysis of Variance of the Effects of Threat of Shock on HR of High and Low Fear of Shock Subjects.

Source	*df*	*MS*	*F*
Experimental Conditions	2	349	6.84*
Fear of Shock	1	99	1.94
Experimental Conditions X Fear of Shock	2	133	2.60
Error	42	51	

* p<.05

*The remaining 14 trials were included in the design for another purpose and will not be reported here.

Orthogonal comparisons[12] revealed the HR increase of the SC–HFS group to be significantly greater than its control group ($F=12.5$, $p<.05$), while no significance was found for the SC–LFS vs. C–LFS comparison. Although both HFS and LFS groups showed an increase in HR with respect to their control groups under the SNC condition, only the LFS orthogonal comparison was significant ($F=6.35$, $p<.05$).

A similar analysis of variance was conducted on the performance data of Figure 2. The summary analysis presented in Table 2 reveals that both main effects are significant.

TABLE 2. Summary Analysis of Variance of the Effects of Shock on Performance Scores of High and Low Fear of Shock Subjects.

Source	*df*	*MS*	*F*
Experimental Conditions	2	4.96	3.39*
Fear of Shock	1	8.82	6.04*
Experimental Conditions X Fear of Shock	2	1.30	.89
Error	42	1.46	

* p<.05

Orthogonal comparisons support the HR data by revealing a significant difference ($F=4.77$, $p<.05$) between SC–HFS vs. C–HFS, but no significance between the SC–LFS vs. C–LFS comparison. However, while both of the SNC groups showed an apparent impairment of performance with reference to their respective control groups, the comparisons were not significant.

Since all subjects were administered the MAS, the distribution of scores on this scale was split at the median and the resulting classification compared with the high and low fear of shock classification. A tetrachoric correlation coefficient of .08 with a corresponding chi square value of .15 ($p>.05$) indicated no relationship between fear of shock and manifest anxiety.

IV. Discussion.

The results offer at least partial support for the original findings of Hodges and Spielberger[2] of a relationship between expressed fear of shock and response to a shock threat situation. However, the most interesting and somewhat unexpected finding of the present study was the differing effects of the shock threat contingencies on both HR and performance for the high and low fear of shock groups. Thus, in comparing the shock contingent and shock noncontingent conditions, it was the HFS group under the shock contingent condition which showed the most pronounced change in HR and performance relative to its control. The LFS group under the same threat condition did not differ from its control in either HR or performance. While the results for the shock contingent threat condition clearly support the original hypothesis of greater performance impairment and HR change under shock threat for HFS subjects, the results for the noncontingent threat condition are some what more ambiguous. Although both HFS and LFS subjects revealed similar changes in HR and performance under this latter condition, there was no evidence to suggest a greater stress response among the HFS subjects. The similarity of the trends for HFS and LFS subjects in both HR and performance data suggests that the noncontingent threat condition probably exerted a weak, but equal stress effect on all subjects regardless of expressed fear of shock. If this interpretation is correct, the significantly greater HR increase for the LFS group relative to its control would be simply a reflection of a general, weak stress effect acting across all subjects.

The question of why the predicted effects of shock threat occurred only under the shock contingent condition is somewhat puzzling. To the extent that this condition was perceived by HFS subjects as allowing a means of controlling the occurrence of shock and thereby offering a way of coping with the stress, it would seem that introducing a threat of shock which is contingent on performance would result in less stress for HFS subjects than the SNC condition in which no control over the stressor was possible. There is evidence from a number of related studies which would suggest that the opportunity for a coping response should reduce stress behavior.[6,9] Such studies, however, have typically been concerned with the effects of ego-defense mechanisms such as denial, reaction formation, or intellectualization in reducing reaction to stress. There is apparently very little experimental evidence to suggest that allowing a subject the means of possibly *avoiding* the occurrence of a stressor through some *instrumental act* would necessarily also serve to reduce stress. Indeed, it is entirely possible that such control could actually enhance the total stress effect. Thus, one of the few studies with results in apparent accord with the findings of the present study is the well-known "executive monkey" study in which animals who could avoid shock through an operant response showed extensive gastrointestinal lesions, while their controls who received the same shocks, but not related to any instrumental response, showed no damage.[8]

The results suggest that under certain conditions the introduction of an apparently appropriate coping response may result in greater stress than a situation in which no control is possible. What the conditions are which determine this is a question for future research. With regard to the SC condition, possibly some degree of control over the occurrence of a stressor serves to reduce stress when threat is not too great. However, when the level of threat becomes excessive, as it may have with the HFS subjects in the present study, control may act to actually increase the stress response.

In neither the present study nor the previous one by Hodges and Spielberger[2] was a relationship found between fear of shock classification and scores on the MAS. A lack of relationship between the MAS and response to threat of shock has recently also been shown for skin resistance activity as well.[4] These results, taken together, suggest that a measure of trait anxiety[10] such as the MAS is considerably less effective in predicting response to a shock stress situation than a measure based upon cognitive appraisal of shock threat. Further research is needed to determine whether measures of cognitive appraisal of threat prove to be as effective in predicting response to stress situations other than shock.

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