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EFFECTS OF STRESS TASK-RELATEDNESS ON LEARNING AND PERFORMANCE

Although many researchers have dealt with the concept of stress, a variety of problems persist. One problem pertains to the effects of stress on performance during and subsequent to different periods of the learning process (Lazarus & Eriksen, 1952; Lazarus, Deese, & Osler, 1952; Deese, 1962; Ryan, 1961; Singer, 1968). Another problem involves the differential effects on performance of various types of stressors (Marteniuk, 1969; Thornton & Jacobs, 1970). Wilkinson (1969) pointed up the need for further investigation of stressors and the effects of practice in relation to various aspects of performance under stress. The effects of experience with one type of stressor upon later performance under other types of stressors have received little or no attention.

One approach to understanding the effects of stress on learning and performance is found in discussions of energy mobilization, activation and arousal (Duffy, 1957; Duffy, 1962; Hebb, 1966; Malmo, 1959; McGrath, 1965; Stennett, 1957). This approach assumes an inverted U type of relationship between activation and performance. Increasing the activation level up to some optimal degree for a particular function increases the quality of performance, however, levels of activation beyond the optimal degree are decremental to performance efficiency. Experimental support for such a position was found by Matarazzo, Ulett, and Saslow (1955) using the Manifest Anxiety scale (Taylor, 1953) as a measure of activation level.

The activation approach would suggest the following: A certain level of arousal may be assumed at the initiation of a task due to motivation to carry out the task and the effort involved in performing the task. As learning taskes place performance would become more automatic, less effort would be expended and a lowered arousal level would ensue. If stress were introduced in the early stages of learning, the combined effects of the arousal due to stress, motivation and effort may rise beyond the optimal degree of arousal with resulting poor performance and poor learning. However, stress introduced during later stages of learning should combine with a lower level of arousal and the quality of performance and the level of learning could be expected to be greater.

Another approach has been that of a drive theory and was summarized by Spence (1958). Of the variables which contribute to the excitatory potential, Spence directed specific attention to drive level, D, and a learning factor, H, (habit strength) which combine in a multiplicative manner. The drive level in aversive situations is a function of the strength of a persisting emotional response in the organism, r_e, that is aroused by the aversive stimulation. Spence discussed three properties of this hypothetical response mechanism, r_e. First, the strength of observable reflexes to noxious stimulation varies directly with the degree of noxiousness of the stimulus. Second, responses to a noxious stimulus exhibit adaption with repetition of the stimulus. Third, individual differences exist in responses to given intensities of stressful stimulation. The Manifest Anxiety scale was used as one operational means to measure such individual difference. Spence stated that the theory was adequate for eyelid conditioning studies, but that it was limited for investigations involving complex human learning.

Spence (1958) also suggested that attention must be directed to the hierarchy of competing response tendencies when dealing with complex learning tasks. Spielberger and Smith (1966) studied the effect of drive on performance during the early stages of learning when the correct response strength was weaker than the incorrect response strength. Using the Manifest Anxiety scale as a measure of drive, they found stronger drive associated with poorer performance in the initial stages of learning. Spence's formulation suggests that, as learning progresses and the correct response strength increases, the performance during later stages of learning is higher for the high drive condition than for the low drive state. Using electric shock to induce the higher drive state rather than using high anxiety subjects, Chiles (1958) also found support for Spence's statements regarding the relationship between learning (habit strength), drive level and performance. While Spence (1958) did acknowledge that high drive states are not always associated with high performance levels, no further explanation was offered.

A complementary approach to the understanding of the effects of stress on learning and performance is found in the suggestions of Easterbrook (1959). He proposed that emotional arousal, or an increase in drive strength, results in a reduction in the range of cues that an organism uses. Thus, under increased drive or arousal a reduction in the utilization of cues can be facilitative if cues unrelated to the task at hand are ignored. However, if the task is complex, the reduction may result in non-utilization of necessary relevant cues and performance becomes less adequate. Using the Manifest Anxiety Scale as a measure of generalized drive, Zaffy and Bruning (1966) inferred from their results that heightened drive is associated with reduced cue utilization in support of Easterbrook's proposal. They also suggested that since the high-anxious subjects ignored irrelevant cues (due to the reduction in the range of cue utilization), the relatively complex task was easier for them than for the low-anxious subjects.

One additional consideration has been proposed by Eason and Branks (1963) in their attention hypothesis. They suggested that performance improves as a subject concentrates on cues relevant to a task and that irrelevant cues which increase the activation level without serving as a source of distraction may lead to further performance improvement. However, performance on the criterion task can be expected to deteriorate if the irrelevant stimuli become sufficiently intense to attract the subject's attention to a significant degree. Eason and Branks found support for the attention hypothesis when studying tension level and performance on verbal and motor tasks carried out simultaneously. Levin (1967) studied induced muscle tension levels in relation to training versus test situations. The inverted U relationship was found under tension-during-test conditions, higher levels of tension led to poorer performance. He suggested that the increased tension reduced the subject's attentiveness to the reinforcement presentations of the criterion task and increased attention to the irrelevant drive state.

Collectively, these approaches seem to point to the value of prior learning before a task is carried out under stressful conditions.

Another aspect of concern in stress research is the concept of "task-relatedness" of stress postulated by Jacobs and Kirk (1969). They studied the effects of no-stress (NS), task-related stress (RS) and task-unrelated stress (US) on the performance of continuous and discrete avoidance tasks. They used mild electric shock as the stressor and found faster reaction time and fewer cumulative response errors for the RS condition than for either the US or NS conditions. There were no differences in reaction times or cumulative response errors between the latter two stress conditions. The results were explained in terms of a "protective-adaptive" mechanism. Subjects are protected by adjusting their behavior so as to avoid the stressor and this is possible in RS conditions but not in US conditions.

Peters (1968) studied the effects of stress on performance with the Howard-Dolman depth perception apparatus and found no differences in errors or reaction times between NS, RS or US conditions. Peters attributed the discrepancy between his findings and those of Jacobs and Kirk to the differences in complexity of the tasks used by the two investigators.

Thornton and Jacobs (1970) found, for a simple reaction time task, an increased reaction time under US but no differences for RS and NS conditions. They suggested that the stress under the US condition functioned as a distracting stimulus. They also used three types of stressors (mild electric shock, threat of shock, and noise) but did not find differences due to the type of stressor. No differences were found for relatedness of stress or type of stress when data from a more difficult task (choice reaction time) were analyzed.

The preceding studies dealing with the task-relatedness of stress have left ambiguities about the effects on performance of RS versus US. For example, the Jacobs and Kirk US condition may be thought of as "threat" of shock (with one reinforcement) leaving the quantity of shock different for the RS and US conditions. A more definitive indication of the differential effects of RS and US would be obtained if the quantity of shock were the same for both conditions.

Lazarus (1969) emphasized the importance of "threat" of a noxious stimulus or of danger as a stressor. Therefore, in the present investigation, threat was included as a stress condition, but was not confounded with task-unrelated stress involving the actual presence of shock as in the Jacobs and Kirk (1969) study. For the purpose of the present study, the term stress refers to any condition which involves actual, threatened and/or perceived discomfort or danger. The term stressor refers to any noxious agent which has the potential to cause discomfort.

The present study investigated the effects on performance of task-related, task-unrelated and threat stress when the stressor was introduced during different stages of practice on a tracking task (pursuit-rotor). Three hypotheses were tested: (1) There would be differences among no-stress, early stress and late stress groups in mean time on target and mean number of errors during the post learning no-stress condition. (2) There would be differences among no-stress, task-related and task-unrelated stress groups in the mean time on target and mean number of errors during the post learning no-stress condition. (3) There would be performance differences among learning groups in the mean time on target and mean number of errors under the various stress conditions.

METHOD AND PROCEDURE

Subjects.--The Ss were 30 male and 30 female volunteer students from introductory psychology classes. Equal numbers of each sex were randomly assigned to the five learning groups and then randomly assigned to the six sequences of the stress performance conditions.

Apparatus.--A photoelectric pursuit rotor (Model 2203F, Lafayette Instrument Co.) was used for the tracking task. A .75 in. by .75 in. illuminated target rotated clockwise at 30 RPM on a circular path. The S's time on target was automatically measured by a .01 sec. timer (Model 20225AD, Lafayette Instrument Co.) and the number of errors were measured by means of an impulse counter (Model 5707A, Lafayette Instrument Co.) capable of counting 600 pulses per minute. Each trial and intertrial interval were automatically controlled by a Repeat Cycle Timer (Model 1, Lafayette Instrument Co.).

Shock was administered by means of an inductorium (Model 3901, Physiological Electronics) which emits a high frequency spiked shock with a 5 milliampere maximum current. Silver coated electrodes, ½in.

by ½in., separated by 1 in. were used.

A VM stereophonic tape recorder (Model 722) was used to record a signal determined by the frequency and duration of OFF target on the pursuit rotor during RS of the learning period. The recorded signal was then used to operate an electronically controlled relay which determined the frequency and duration of electric shock during the US condition.

A Recording GSR Apparatus (Model 12-13R, Marietta Apparatus Co.) was used to measure skin resistance levels. Silver coated finger electrodes were used with B & K electrode jelly.

Procedure.--Each S underwent the appropriate experimental conditions individually and the total session for each S lasted approximately one hour.

Upon reporting for the experiment, each S was given a brief explanation as to the general purpose of the study. GSR electrodes were attached to the forefinger and ring finger of his nonpreferred hand and electric shock electrodes were placed on the ankle of the same side. Three ascending determinations of a shock threshold were made to introduce the S to the shock measurement procedure. Shock level was then gradually increased until the S reported that it was unpleasant and uncomfortable but not painful. The highest value of three determinations was used as the shock level for that S. Ss were always informed as to when they would receive shock and shock electrodes were disconnected during non-shock trials.

All Ss tracked, with a stylus, an illuminated target rotating on a circular path at 30 RPM. A trial consisted of a 30 second period of tracking. Each trial was followed by a 15 second test interval with 1 minute intervals when further instructions were to be given. Two types of measures were recorded for each trial: time on target (to the nearest .01 sec.) and number of errors.

During the learning period, (trials 1-24) Ss underwent conditions according to the schedule for the group to which they had been randomly assigned (see Table 1). A 1 minute rest period followed trials 3, 12 and 21 to allow for presentation of appropriate instructions. During RS, S could avoid the shock by tracking accurately but received shock continuously when he was not on the target. During US, S received shocks whether or not he was tracking accurately. The frequency and duration of shock presentation was determined in the following manner. A continuous tape recording was made of the frequency and duration of the shock administered to each S in the RS condition. The same sequence and duration of shock was administered during the US condition to Ss who had been randomly paired according to the same sex and subgroup (early, late). Thus the frequency and duration of shock administered for the RS and US conditions was equated.

During the stress performance period (trials 25-33), one male and one female from each of the five learning groups was randomly assigned to each of the six possible sequences of the three stress conditions. Three trials were given for each stress condition with 1 minute instruction and rest periods between conditions. Each S performed the tracking task under all three stress conditions: RS, US, and threat-stress (TS). The TS condition consisted of telling Ss that a final pain threshold for shock would be determined upon completion

TABLE 1

Learning Period Schedule

Group	Trials			
	1-3	4-12	13-21	22-24
NS	NS	NS	NS	NS
ERS	NS	RS	NS	NS
LRS	NS	NS	RS	NS
EUS	NS	US	NS	NS
LUS	NS	NS	US	NS

NS - No stress
RS - Task-related stress
US - Task-unrelated stress

E - Early
L - Late

of the next three non-shock trials. No shock was administered during the trials. Following the trials Ss was told a mistake had been made and the pain determination was not required for his group. One male and one female preliminary S tracked under NS through trials 1-24 and then performed three trials under the RS condition. The frequency and duration of shocks for the male and for the female were then used for all like-sexed Ss under the US condition.

Following the last trial, each S was handed a card listing the words and phrases of the Perceived Stress Index (PSI) (Jacobs and Munz, 1968) and asked to select the word or phrase which best describes how he felt during each period of the experiment and then how he felt normally. The periods each S rated were trials 1-3, 4-12, 13-21, 22-24, and each of the final stress conditions or trials 25-27, 28-30, 31-33.

RESULTS

Values determined by Hartley's F_{max} test indicated that the assumption of homogeneity of variance was tenable for sex and stress group variables on all measures. However, the F_{max} ratios were significant ($p < .05$) for all repeated measures. Therefore, all tests involving repeated measures were evaluated in accordance with the Geisser-Greenhouse conservative (F_c) test (Kirk, 1968). Unless indicated otherwise, all tests are two-tailed tests and are considered significant when $p < .05$.

Learning period.--Analysis of variance for a split-plot factorial design yielded significant F ratios for sex on both the time on target data F (1,50)=7.27, $p < .01$ and the error data F (1,50)=9.63, $p < .01$. Males were on target longer ($\bar{X}$ = 22.23 sec.) than females ($\bar{X}$ = 19.65 sec.) and committed fewer errors ($\bar{X}$ = 31.5) than did females ($\bar{X}$ = 39.2).

Trials were significant for time on target data, F_c (1,50) = 24.20, $p < .01$ and error data, F_c (1,50) = 9.20, $p < .01$. Dunn's multiple comparison procedure for means revealed a number of differences between trial means as significant. In general, time on target increased from the first to the eighth trials and the number of errors tended to decrease from the first to the eighth trial. Stress groups effect was not significant for time on target F (4,50) = 2.06, $p > .05$ and errors, F (4,50) = 2.29, $p > .05$. The following interactions were not significant: for time on target, Stress group X Sex F (4,50) = 2.26, $p > .05$, Stress group X Trials F_c (4,50) = 1.56, $p > .05$, Sex X Trials F_c (1,50) = .46, $p > .05$, Stress group X Sex X Trials F_c (1,50) = 1.08, $p > .05$; for errors, Stress group X Sex F (4,50) = .89, $p > .05$, Stress group X Trials F_c (4,50) = 1.14, $p > .05$, Sex X Trials F_c (1,50) = 2.26, $p > .05$, Stress group X Sex X Trials F_c (1,50) = .76, $p > .05$.

Stress performance period.--Analysis of variance for a split-plot factorial design yielded significant F ratios for sex with time on target data, F (1,50) = 5.78, $p < .01$, and with error data, F (1,50) = 13.33, $p < .01$. Males were on target longer ($\bar{X}$ = 24.31 sec.) than females ($\bar{X}$ = 22.12 sec.) and committed fewer errors ($\bar{X}$ = 25.9) than did females ($\bar{X}$ = 34.6). F ratios for stress groups were not significant for either time on target data F (4,50) = 1.42, $p > .05$ or error data, F (4,50) =

2.42, $p > .05$. The interaction of Stress group X Sex was not significant for time on target F (4,50) = 1.97, $p > .05$, or for errors F (4,50) = 1.52, $p > .05$.

The F ratio for stress condition was significant for the error data, F_c (1,50) = 6.23, $p < .05$. The mean errors for the RS, US and TS conditions were 31.6, 30.3 and 29.0, respectively. Comparisons between the stress conditions indicated that only the difference between mean errors for RS and TS was significant t (59) = 3.55, $p < .01$. All interactions for the error data were not significant: Stress group X Sex F (4,50) = 1.52, $p > .05$, Stress group X Stress condition F_c (4,50) = 1.88, $p > .05$, Sex X Stress condition F_c (1,50) = 1.62, $p > .05$, Stress group X Sex X Stress condition F_c (4,50) = 1.12, $p > .05$.

Time on target data was significant for stress condition F_c (1,50) = 16.72, $p < .01$, Stress group X Stress condition F_c (4,50) = 24.32, $p < .01$, but not significant for Sex X Stress condition F_c (1,50) = .48, $p > .05$. Tests of simple main effects, with Stress group X Stress condition significant, indicated that none of the differences between stress groups at each stress condition were significant. However, differences between the stress conditions for each stress group were found to be significant: for NS group F_c (1,50) = 8.04, $p < .01$, for ERS group F_c (1,50) = 4.80, $p < .05$, for LRS group F_c (1,50) = 21.76, $p < .01$, for EUS group F_c (1,50) = 44.20, $p < .01$, for LUS group F_c (1,50) = 35.28, $p < .01$. Differences between stress conditions for each stress group are presented in Figure 1, The NS group were on target longer under TS ($\bar{X}$ = 23.54) than under either RS ($\bar{X}$ = 22.74) or US ($\bar{X}$ = 23.01). The

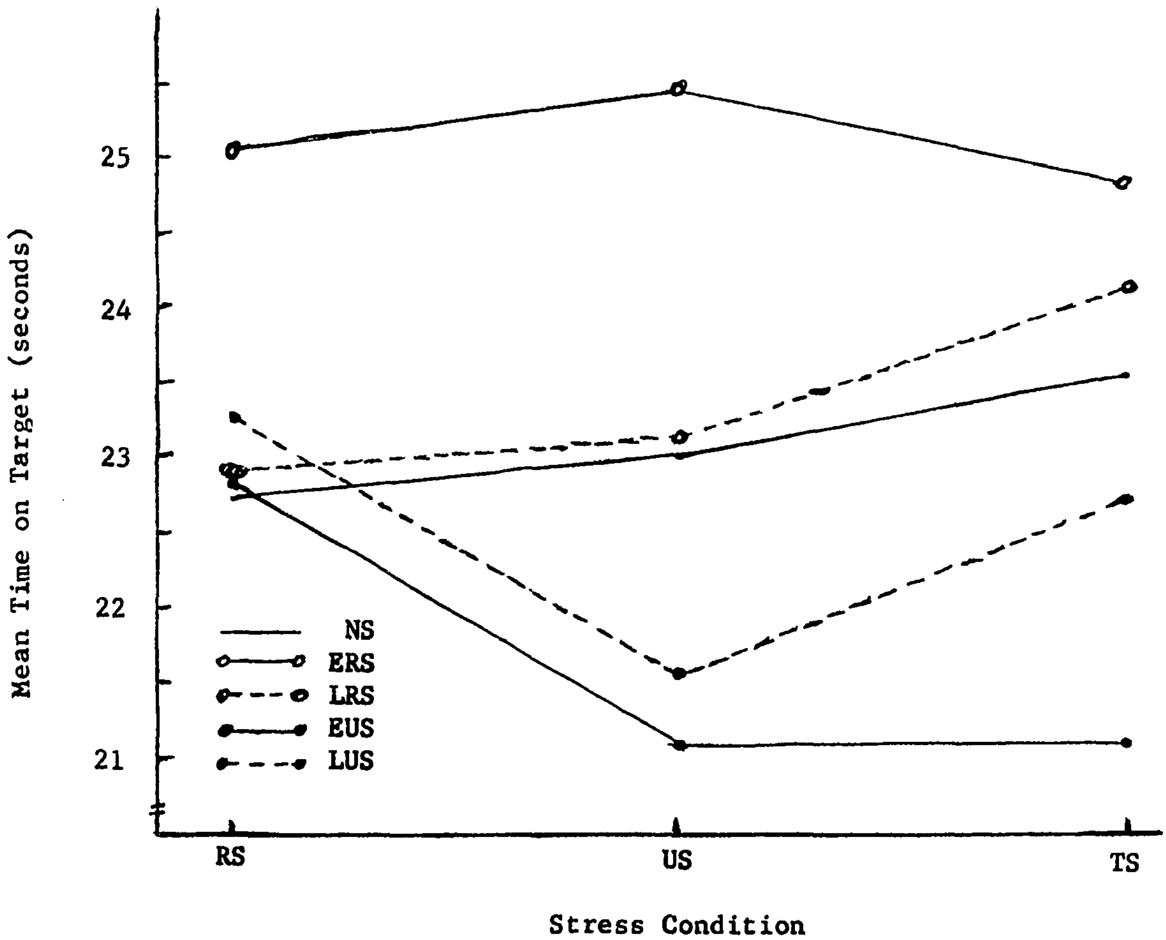

Figure 1. Interaction of stress group and stress condition.

difference between the latter two conditions was not significant. Only the difference between US and TS was significant for ERS group with greater time on target for the US ($\bar{X}$ = 25.46) condition than the TS ($\bar{X}$ = 24.84) condition. For the LRS group, significantly less time on target occurred during RS ($\bar{X}$ = 22.90) than either US ($\bar{X}$ = 23.12) or TS ($\bar{X}$ = 24.16). The difference between US and TS was not significant for the EUS group. However, the time on target during US ($\bar{X}$ = 21.58) was significantly less than during TS ($\bar{X}$ = 22.71) for the LUS group.

Tests for simple effects, with Stress group X Sex X trials significant, were conducted. The general patterns of interaction are presented in Figure 2 and Figure 3. Significant differences were found between stress groups for females under the US and TS conditions. Difference between RS, US, and TS were significant for males (except ERS) and for females. Males in EUS and LUS groups spent significantly more time on target than did the females. The performance differences for other combinations of stress group and stress condition did not approach significance.

Perceived stress index (PSI). -- An analysis of variance of PSI scale values for RS, US, TS and N (normal) conditions revealed significant differences only between stress groups F (4,50) = 2.90, $p < .05$, and between stress conditions, F_c (1,50) = 62.58, $p < .01$. Dunn's multiple comparison procedure indicated one significant difference between stress groups, NS and ERS ($p < .05$). Scale values on the PSI were used rather than the score recommended by Jacobs and Munz (1968) so that each stress condition could be compared with the S's "normal" perceived state. Comparisons between stress conditions indicated significant differences ($p < .01$) between RS and TS, RS and N, US and TS, US and N. Figure 4 shows the PSI trends for each stress group throughout all conditions.

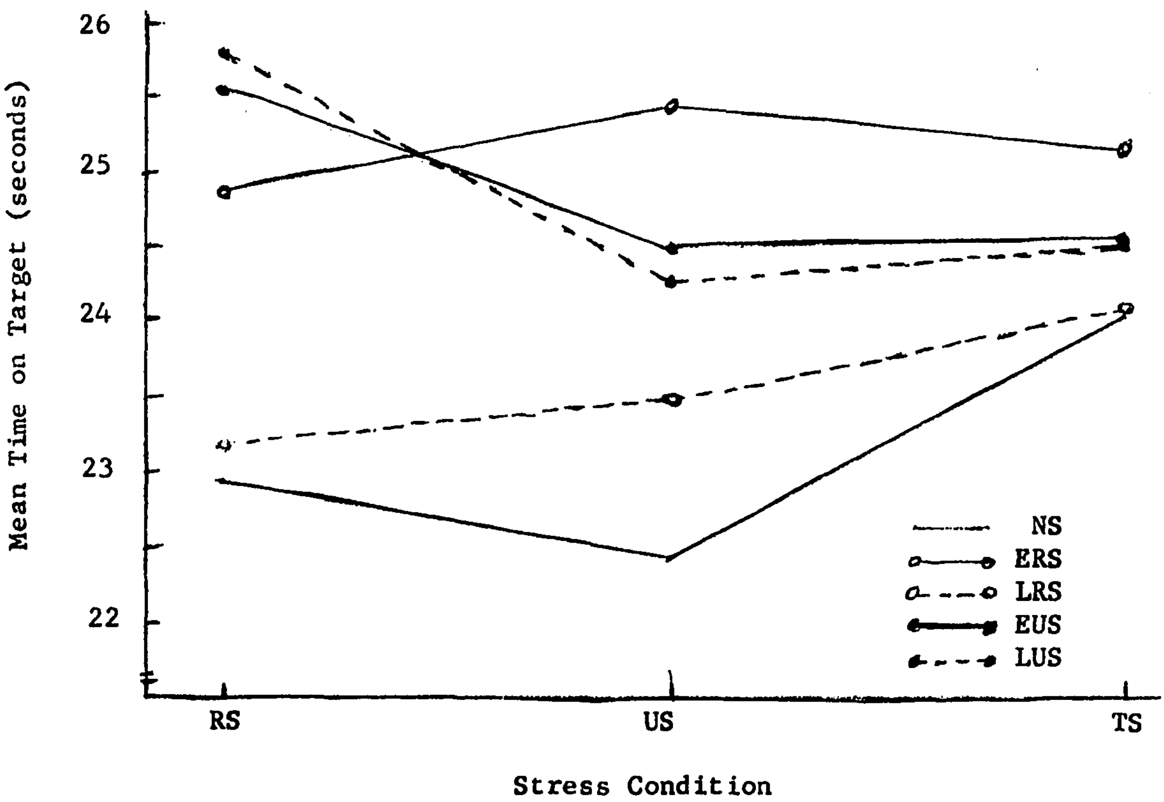

Figure 2. Interaction of stress group and stress condition for males.

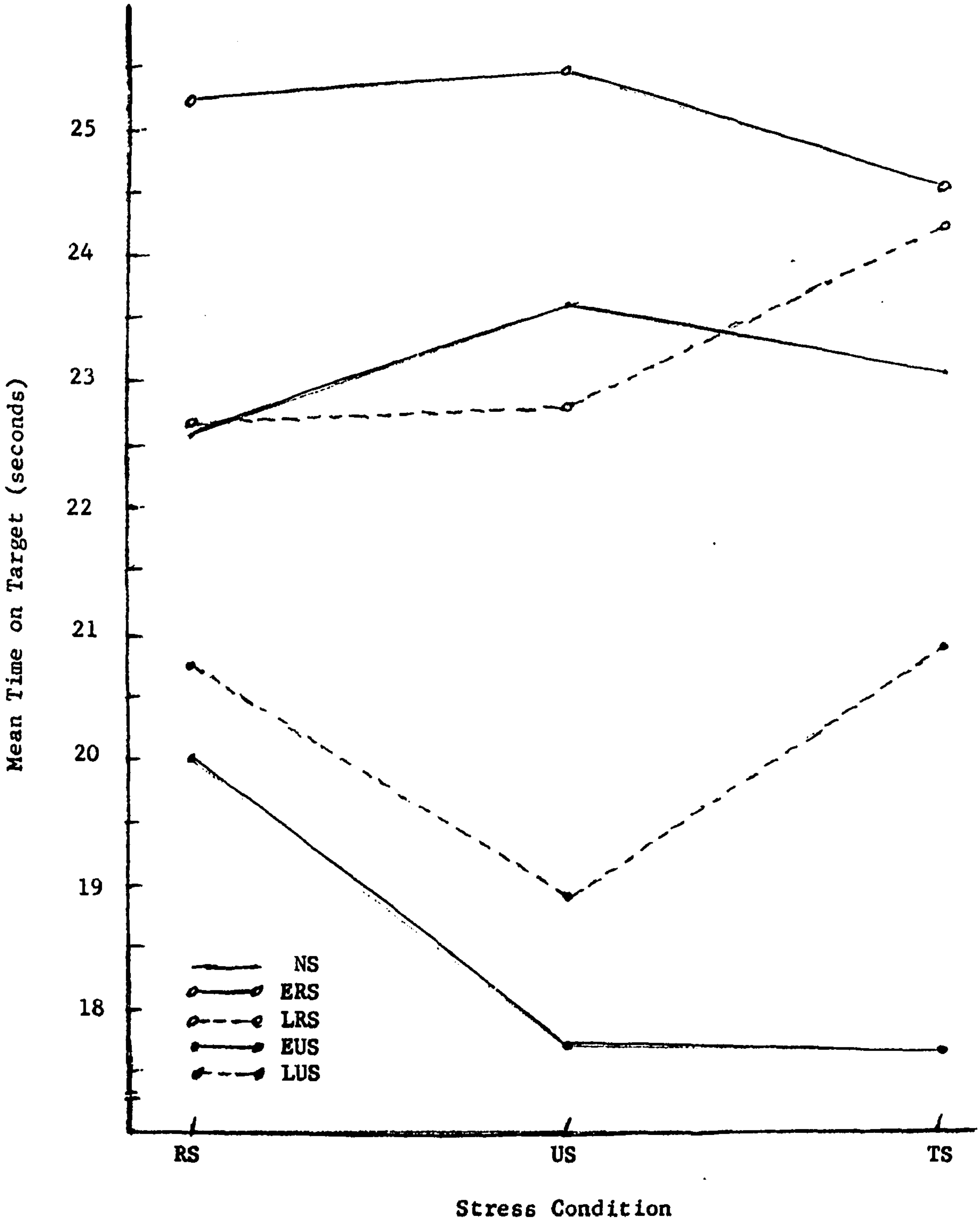

Figure 3 Interaction of stress group and stress condition for females.

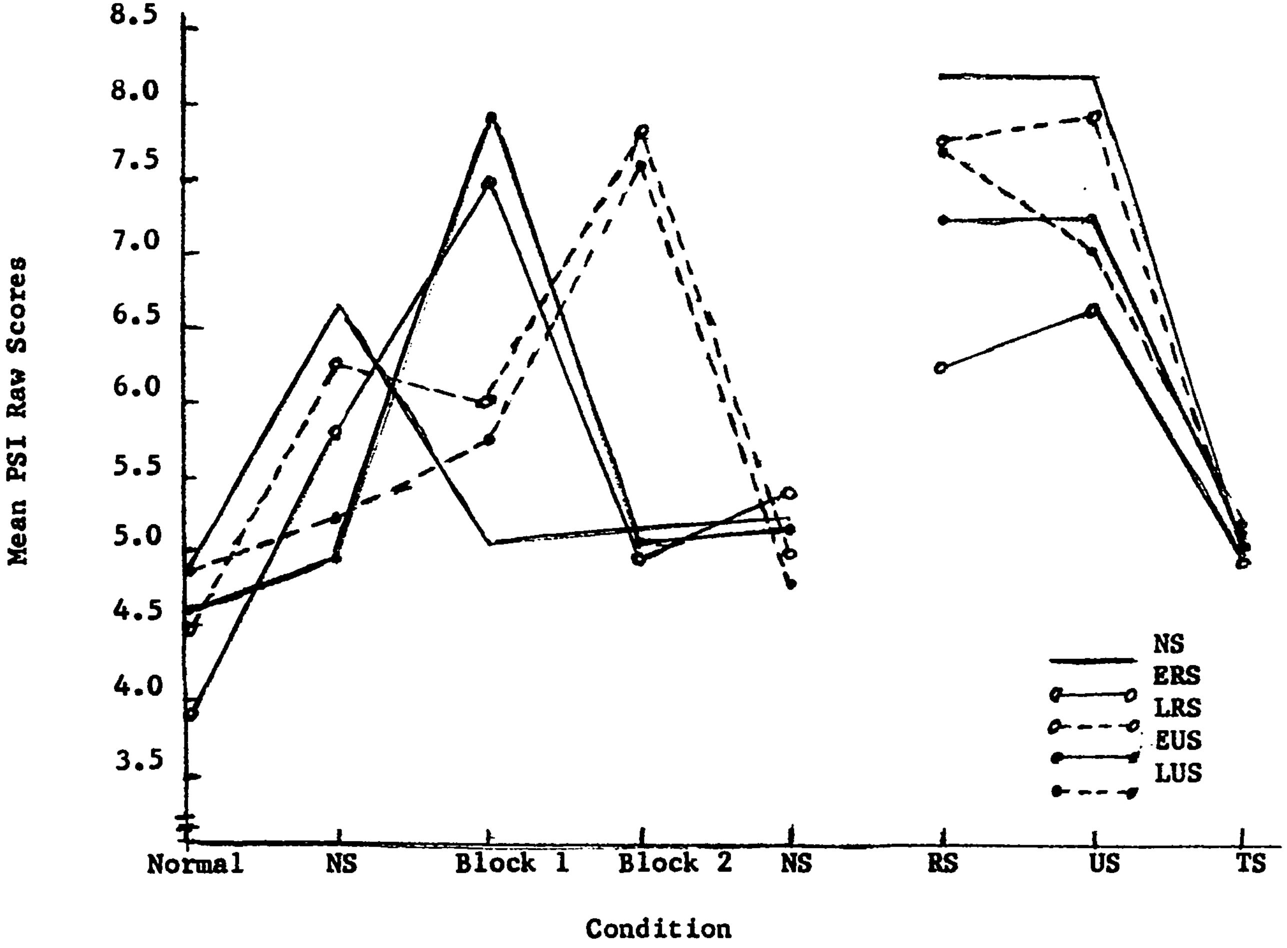

Figure 4. PSI ratings by stress group for the various conditions throughout the experiment.

Skin conductance. -- An analysis of variance of skin conductance measures for RS, US, and TS yielded significant values for sex, F (1,50) = 8.24, $p < .01$, for stress condition, F_c (1,50) = 21.08, $p < .01$, for Stress group X Stress condition, F_c (4,50) = 6.42, $p < .01$, and Stress group X Sex X Stress condition, F_c (4,50) = 2.91, $p < .05$. Non-significant were stress group, F (4,50) = 2.20, $p > .05$, Stress group X Sex, F (4,50) = 1.11, $p > .05$, and Sex X Stress condition, F_c (1,50) = .83, $p > .05$. Dunn's multiple comparison procedure indicated significant RS - US $p < .05$, RS - TS $p < .01$, US - TS $p < .01$. Figure 5 shows the skin conductance trends for each stress group throughout all conditions.

DISCUSSION

Learning period. -- The analysis of the time on target data and of error data did not yield differences between stress groups or Stress group X trial interaction. Neither of the first two hypotheses were supported. The timing of stress conditions during the learning period did not affect the Ss' performance on the post learning no-stress trials. The type of stress relatedness, RS or US, did not affect the Ss' performance on the post learning no-stress trials.

The prediction that learning would be better if stress were not introduced during the early stages of practice was not supported. An examination of mean change for possible trends from the initial to the final learning trials did not reveal consistent or significant tendencies. For the time on target data, stress introduced late resulted in a greater increase in time on target ($\bar{X}$ = 4.47 sec.) than when stress was introduced

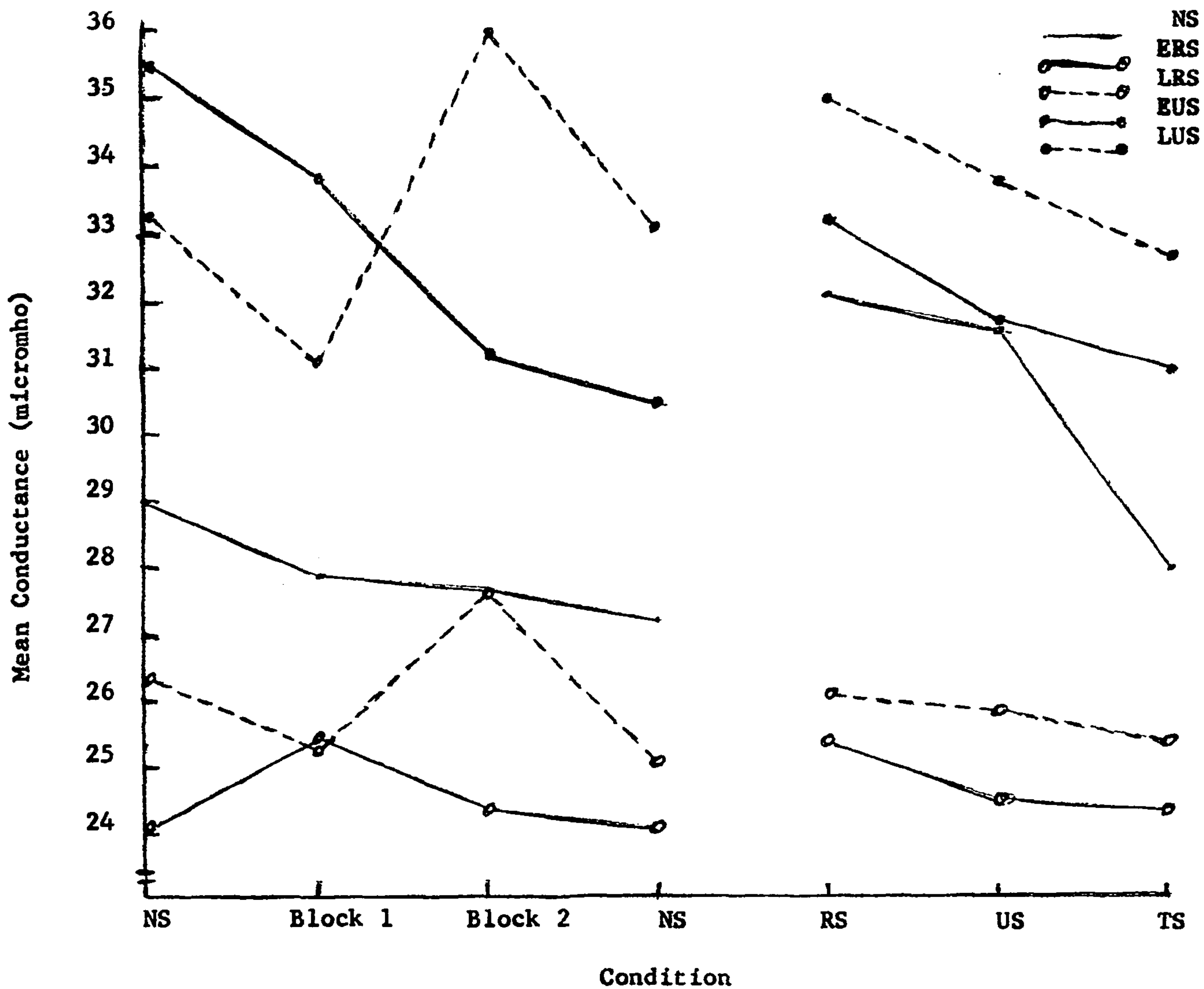

Figure 5. Skin conductance by stress groups for the various conditions throughout the experiment.

early ($\bar{X}$ = 2.40 sec.). Just the opposite was found with the error data. Stress introduced during early trials resulted in a greater reduction of errors ($\bar{X}$ = 7.10) than when stress was introduced later ($\bar{X}$ = 6.40).

The prediction that the stress related groups would differ on NS post learning trials was not supported. Again, an examination of mean change for possible trends from the first to the last learning trials did not reveal consistent or significant tendencies. The NS group was on target more ($\bar{X}$ = 6.52 sec.) than were the stress groups ($\bar{X}$ = 3.44 sec.), with RS improving more ($\bar{X}$ = 3.56 sec.) than US ($\bar{X}$ = 3.33 sec.). However, the stress groups had a greater reduction of errors ($\bar{X}$ = 6.75) than did the NS group, and the US groups showed a greater reduction ($\bar{X}$ = 6.90) than did the RS groups ($\bar{X}$ = 6.60). If there are subtle effects of early vs. late, or task-related vs. task-unrelated stress on learning, these may have been masked by considerable S variability and relatively small sized stress groups (N = 12). Further stress research must consider the aspect of performance being measured (time or accuracy). However, Marteniuk (1969) compared the performance of related arousal (RA), unrelated arousal (URA) and control (C) groups on a ball snatch task. The last five trials were carried out under a no-shock condition. There were no significant overall differences between his RA, URA and C groups on the final no-shock condition. Ryan (1961) used electric shock to produce tension while Ss balanced on a stabilometer. He found that the rate of learning was independent of the tension induced but that the shock did affect performance. Thus, the introduction of stress in the form of mild shock during learning does not appear to affect learning but does affect performance. Evidence thus far accumulated does not substantiate a relationship between task-relatedness of stress and learning.

Stress period.--The third hypothesis was not supported. Significant differences between stress groups were not found for each stress condition. However, differences were significant between stress conditions. The mean errors for the RS condition differed significantly from the mean errors for the TS condition. This indicated that the Ss committed more errors under the RS condition than the TS. An opposite result was found for time on target data. The performance of Ss under the RS condition was better than for the US condition but did not differ from the TS condition. The time on target performance during the TS condition was found to be better than that for the US condition. Data for PSI indicate that both RS and US were perceived as significantly more stressful than TS or the Ss' normal state. The PSI differences between RS and US were not significant. Significant skin conductance differences indicate the RS condition to have been the most stressful ($\bar{X} = 30.4$), followed by the US condition ($\bar{X} = 29.5$) and the TS condition ($\bar{X} = 28.3$).

Jacobs and Kirk (1969) found faster reaction times for RS condition than US or NS and no difference between US and NS. Marteniuk (1969) found RS superior to US and NS and no difference between US and NS. Both of these studies used instructions involving expectation of shock as the primary element in the US condition while the present study used actual presentation of shock. Their US conditions are more like the TS of the present study than the US. When the US involves repeated actual shock, US and TS differences occur, with Ss performance poorer under the US. This supports the importance of task-relatedness as a variable. One factor in common to all three studies was the use of some measure of performance time. RS performance time was shown in all three studies to be superior to US performance time. When a different performance measure, as errors, was employed in the present study, performance for RS was poorer than for TS. Careful attention should be given to the measures of performance utilized in future studies of stress.

Stress group X Stress condition interaction was significant and an interesting finding occurs (See Figure 4). The difference, RS - US, was not significant for NS or ERS and LRS, but the RS - US difference was significant for EUS and LUS. Both US stress groups were on target more under the RS condition than the US. Although non-significant, the direction of difference for RS stress groups indicated slightly more time on target under the US condition. That RS and US stress groups did poorer under the stress condition they had experienced during learning, would suggest that previous experience with RS or US may adversely affect later performance under the same type of stress condition.

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APPENDICES

APPENDIX I

PROSPECTUS

APPENDIX I

DISSERTATION PROSPECTUS

EFFECTS OF STRESS TASK-RELATEDNESS ON LEARNING AND PERFORMANCE

As people listen to news media they are constantly reminded of the critical times facing them today. Armed conflicts between nations are reported daily. Protest movements, riots and violence erupt reminding the populace of pressing unsolved problems. Young people seem to feel pressures to attend college and young men live with the possibility of being drafted for military service and eventually facing danger. These reflect but a small portion of the pressures men feel daily. Dangers exist during natural disasters and the threat of danger is associated with aspects of various occupations. The presence of such pressures, demands, threats and dangers indicates that man is subjected to much stress during his lifetime and an understanding of stress and its effects is of considerable value.

THE CONCEPT OF STRESS

Although an immense volume of research dealing with stress has accumulated, no one definition is as yet sufficient to encompass the variety of meanings indicated by the term. An overall perspective of the concept can be gained by a review of definitions of stress and a consideration of stressors.

A number of emphases are found with definitions of stress. Selye (1956) studied physiological processes and defined stress as "... the state manifested by a specific syndrome which consists of all the non-specifically induced changes within a biologic system" [p.54]. Thiesen, Forgus and Spaner (1964) emphasized a response of sustained physiological tension and suggested that the adaptive mechanisms are taxed or strained. An external dimension was suggested by Indik (1964) in his definition of stress as "... a force or set of forces that impinge on the individual such that the adaptive demands on the individual exceed his normal homeostatic capacities and therefore produce a force toward continuing or permanent change in the individual" [p.22].

Attention to the external situation (or to stimulation) was emphasized by Langer and Michael (1963) who said that stress signifies "... the environmental force pressing on the individual" [p.6]. They also felt that "... the reaction to stress and the stress itself must be kept conceptually distinct ..." [p.6]. Others, as Howard and Scott (1965) and Shaffer (1954), have discussed stress in terms of the relationship between an organism and its environment. Janis (1958), however, used stress "... to characterize either the disruptive stimuli (e.g. 'stress situation') or the changes in overt behavior, effect or attitude that are evoked by the disruptive stimuli (e.g. 'stress reactions')" [p.13].

Another aspect expressed in several definitions has been the psychological state and characteristics of persons. Beier (1951) discussed the perception of threat and consequent anxiety in relation to the term stress. Lazarus (1966) suggested that threat is a key intervening variable of psychological stress. Cofer and Appley (1967) reviewed a number of definitions and then defined stress as "... the state of an organism where he perceives that his well-being (or integrity) is endangered and that he must devote all of his energies to its protection" [p.453]. After reviewing definitions, Deese (1962) remarked "It will be useful to characterize as stressful those conditions which elicit reports of discomfort. Such a notion should make it easier to understand the varieties of social and psychological situations in which the term stress has been used ..." [p.205]. Lazarus (1969) recently summarized the present situation in regard to the meaning of the term stress.

> It should now be clear that the term "stress" contains a great diversity of meanings. It is both a stimulus and a reaction; it comprises physiological as well as psychological conditions and processes. When the term "stress" is used colloquially, there is often no indication of which of these meanings is intended. The term is thus diffuse, unspecific, and sometimes confusing. Yet in all the usages of the word "stress" there is a common core of meaning which gives the term its vitality and value in communication. Stress always has the implication of an event that in some way harms or threatens to harm the person because it is perceived to exceed his resources to cope with it. This is implied whether the harm is real or imagined, whether it involves direct assault on the tissues or merely anticipated assault, whether the harm is mild or severe.
>
> In consequence of the diversity of meaning, and yet the presence of common connotations, the concept of stress must be regarded as a very general one standing for a large field of inquiry. Stress is not one specific thing, but many. The distinctions in meaning must be made by providing separate terms for each of the many processes that are subsumed within the general rubric. Thus, there are physiological stress processes and psychological stress processes. There is a stress stimulus and a stress reaction. [p.172-173]

An examination of studies of stress reveals something of the variety of situations and conditions which have been described as stressful. These situations and conditions have usually been referred to as stressors. In general, two types of studies have been carried out, field studies and experimental or "laboratory" studies.

In field studies, peoples' reactions have been studied during natural disasters such as floods, mine cave-ins, etc. Military men have been studied during training with simulated battle conditions using live ammunition and during actual battle conditions. Studies of men learning to parachute have been reported. A variety of studies dealing with conditions affecting men during exploration have been done. Both astronauts and aquanauts perform under the threat of danger of life. Parents of children dying of leukemia have been studied as have medical patients during pre- and post-surgery periods.

A variety of stimuli have been employed as stressors in experimental investigations. To qualify as stressors, these have been either of high intensity, of long duration and/or noxious, painful, or unpleasant or some combination of these. Some stimuli would be best described as distracting. Even isolation and sensory deprivation conditions have been considered as stressors.

Another group of stressors used in experimental studies pertain to the task to be performed. Thus, difficult or complex tasks have been considered stressful. Tasks involving difficult discriminations, ambiguity, or difficult decisions have been used as stressors. Overloads involving time pressures or pacing (including high information input rates, high information processing rates and/or high response rates) have been used. At the other end of the continuum, conditions of underload and deprivation also have been considered as stressful.

Experimenters have referred to certain subjective states of subjects as being stressful. Thus any condition involving threat, anxiety or discomfort has been labeled as a stressor. Anxiety as measured by the Rorschach or by Taylor's Manifest Anxiety scale has been considered as stress. Films of surgical operations and of accidents as well as photographs of persons who died traumatically have been used to induce subjective states of stress. Failure induced by instructions, by presentation of false norms, by unsolvable problems, and by low probabilities of success have been employed.

Many stressors may be classified in terms of their task-relatedness. In task-related stress a noxious condition must be associated with the performance of a task and an individual may respond in some manner so as to avoid or escape the noxious condition while performing the task. A subject may avoid a noxious stimulus by performing a task without error or by performing within certain prescribed time limits. At the other end of the relatedness continuum are stressors described as task-unrelated. A stressor (e.g. noxious stimulus) impinges on an individual and it happens that he must carry out some task at the same time. The implication is that a person is subjected to the stressor whether he does or does not engage in the task, however, it happens that he performs the task while the stressor is present.

For the purpose of the present study, the term stress will be used to refer to any situation which involves actual, threatened and/or perceived discomfort or danger. The term stressor will refer to any noxious agent which has the potential to cause discomfort or danger.

PROBLEM

Although many studies have dealt with the concept of stress, a variety of problems remain unsolved. One problem is concerned with the effects of stress on performance during and subsequent to different periods of the learning process. More information is needed about the differential effects on performance of different types of stressors. The effects of experience with one type of stressor upon later performance under other types of stressors has received little or no attention. Since people frequently must carry on everyday functions under stressful conditions, questions arise as to when and what type of stressor should be introduced to accomplish the greatest efficiency in the eventual performance of a task under a variety of stressful conditions. It is to these general questions that the present study is directed.

Recently Singer (1968) emphasized the practical need for understanding the effects of stress on learning and performance of motor skills. Lazarus and Eriksen (1952) indicated that more knowledge was needed concerning when stress is imposed in the learning and performance of a task. Lazarus, Deese, and Osler (1952) hypothesized that stress would be more detrimental during early practice than later practice. Ten years later, Deese (1962) suggested that while adaptation may account for some of the results in related studies, no evidence has supported the hypothesis. He then presented the idea that the effects of stress would depend upon the components involved in a skill and that components change as a function of practice.

One approach to understanding the effects of stress on learning and performance is found in the discussions of energy mobilization, activation and arousal. This general approach (Duffy, 1957; Duffy, 1962; Hebb, 1966; Malmo, 1959; McGrath, 1965; Stennett, 1957) may be represented by Malmo's (1959) statement that " . . . the relation between activation and behavioral efficiency (cue function or level of performance) is described by an inverted U curve" [p.368]. Thus increasing the activation level beyond the optimal degree is associated with a decline in performance efficiency. Experimental support for such a position has been found using the Manifest Anxiety scale (Taylor, 1953) as a measure of activation level (Matarazzo, Ulett, and Saslow, 1955).

The activation approach would suggest the following: A certain level of arousal may be assumed at the initiation of a task due to motivation to carry out the task and the effort involved in performing the task. As learning takes place performance would become more automatic, less effort would be expended and a lowered arousal level would ensue. If stress were introduced in the early stages of learning the combined effects of the arousal due to stress, motivation and effort may rise beyond the optimal degree of arousal with resulting poor performance and learning. However, stress introduced during later stages of learning should combine with a lower level of arousal and the quality of performance and the level of learning could be expected to be greater.

Amother approach has been that of a drive theory and was summarized by Spence (1958). Of the variables which contribute to the excitatory potential, Spence directed specific attention to drive level, D, and a learning factor, H, (habit strength) which combine in a multiplicative manner. The drive level in aversive situations is a function of the strength of a persisting emotional response in the organism, r_e, that is aroused by aversive stimulation. Spence discussed three properties of this hypothetical response mechanism, r_e. First, the strength of observable reflexes to noxious stimulation varies directly with the degree of noxiousness of the stimulus. Second, responses to a noxious stimulus exhibit adaptation with repetition of the stimulus. Third, individual differences exist in responses to given intensities of stressful stimulation. The Manifest Anxiety scale (or A-scale) was used as one operational means to measure such individual difference. Spence stated that the theory was adequate for eyelid conditioning studies, but that it was limited for investigations involving complex human learning.

Spence (1958) also suggested that attention must be directed to the hierarchy of competing response tendencies when dealing with complex learning tasks. Spielberger and Smith (1966) studied the effect of drive on performance during the early stages of learning when the correct response strength was weaker than the incorrect response strength. Using the Manifest Anxiety scale as a measure of drive, they found stronger drive associated with poorer performance in the initial stages of learning. Spence's formulation suggests that as learning progresses and the correct response strength increases, the performance during later stages of learning is higher for the high drive condition than for the low drive state. Using electric shock to induce the higher drive state rather than using high anxiety subjects, Chiles (1958) also found support for Spence's statements regarding the relationship between learning (habit strength), drive level and performance. While Spence (1958) did acknowledge that high drive states are not always associated with high performance levels, no further explanation was offered.

A complementary approach to the understanding of the effects of stress on learning and performance is found in the suggestions of Easterbrook (1959). He proposed that emotional arousal, or an increase in drive strength, results in a reduction in the range of cues that an organism uses. Thus under increased drive or arousal a reduction in the utilization of cues can be facilitative if cues unrelated to the task at hand are ignored. However, if the task is complex, the reduction may result in non-utilization of necessary relevant cues and performance becomes less adequate. Using the Manifest Anxiety scale as a measure of generalized drive, Zaffy and Bruning (1966) inferred from their results that heightened drive is associated with reduced cue utilization in support of Easterbrook's proposal. They also suggested that the high-anxious subjects ignored irrelevant cues (due to the reduction in the range of cue utilization), therefore the task was easier for them than for the low-anxious subjects.

One additional consideration has been proposed by Eason and Branks (1963) in their attention hypothesis. They suggested that performance improves as a subject concentrates on cues relevant to a task and that irrelevant cues which increase the activation level without serving as a source of distraction may lead to further performance improvement. However, performance on the criterion task can be expected to deteriorate if the irrelevant stimuli become sufficiently intense to attract the subject's attention to a significant degree. They found support for the attention hypothesis when studying tension level and performance on verbal and motor tasks carried out simultaneously. Levin (1967) studied induced muscle tension levels in relation to training versus test situations. The inverted U relationship was found under tension-during-test conditions, higher levels of tension led to poorer performance. He suggested that the increased tension reduced the subject's attentiveness to the reinforcement presentations of the criterion task and increased attention the the irrelevant drive state.

Collectively, these approaches seem to point to the value of prior learning before a task is carried out under stressful conditions.

Another aspect of concern in stress research is the concept of "task-relatedness" of stress postulated by Jacobs and Kirk (1969). They studied the effects of no-stress (NS), task-related stress (RS) and task-unrelated stress (US) on the performance of continuous and discrete avoidance tasks. They used mild electric shock as the stressor and found faster reaction time and fewer cumulative response errors for the RS condition than for either the US or NS conditions. There were no differences in reaction times of cumulative response errors between the latter two stressor conditions. The results were explained in terms of a "protective-adaptive" mechanism. Ss are protected by adjusting their behavior so as to avoid the stressor and this is possible in RS conditions but not in US conditions.

Peters (1968) studied the effects of stress on performance with the Howard-Dolman depth perception apparatus and found no differences in errors or reaction times between NS, RS or US conditions. Peters attributed the discrepancy between his findings and those of Jacobs and Kirk to the differences in complexity of the tasks used by the two investigators.

Thornton and Jacobs (1970) found, for a simple reaction time task, an increased reaction time under US but no differences for RS and NS conditions. They suggested that the stress under the US condition functioned as a distracting stimulus. They also used three types of stressors (mild electric shock, threat of shock, and noise) but did not find significant differences due to the type of stressor. No significant differences were found for relatedness of stress or type of stressor when data from a more difficult task (choice reaction time) were analyzed.

The preceding studies dealing with the task-relatedness of stress have left ambiguities about the effects on performance of RS versus US. For example, the Jacobs and Kirk US condition may be thought of as "threat" of shock (with one reinforcement) leaving the quantity of shock different for the RS and US conditions. A more definitive indication of the differential effects of RS and US would be obtained if the quantity of shock were the same for both conditions.

However, as mentioned earlier, Lazarus (1969) has suggested that an important stressor (or stress condition) is "threat" of a noxious stimulus or danger. Therefore, in the present investigation "threat" of stress (TS) will be included as a stress condition, but will not be confounded with US involving actual presence of shock as in the Jacobs and Kirk (1969) study.

Wilkinson (1969) recently reviewed studies dealing with the effect of environmental stressors on performance. The stressors he discussed are noise, heat, sleep deprivation, alcohol, hypoxia, acceleration and vibration. After discussing familiarity with the stressor and practice on the task as important variables, he concluded that "Clearly, more research is needed to define those stresses and those aspects of performance under stress in which prior practice will lead to positive or negative transfer" [p.263]. Although he did not discuss task-relatedness of stressors, task-relatedness would seem to be an important variable when one is considering practice under stressors and subsequent performance under stressors.

Purpose.--The purpose of the present investigation is to study the effects on performance of RS and US when the stressor introduced during different stages of practice on a tracking task (pursuit-rotor). The effects on performance during the initial introduction of the stressor and upon later performance under the same or different stress conditions will be of interest.

Hypotheses.--The following hypotheses will be tested:

> There will be differences among no-stress, early stress, and late stress groups in the mean time on target and mean number of errors during the post learning no-stress condition.

> There will be differences among no-stress, task-related stress and task-unrelated stress groups in the mean time on target and mean number of errors during the post learning no-stress condition.
>
> There will be performance differences among learning groups in the mean time on target and mean number of errors under various stress conditions.

The 5% level of significance will be used as a basis for rejecting the null hypothesis. All tests will be two-tailed tests of significance.

METHOD AND PROCEDURE

Subjects.--Sixty students (30 male, 30 female) from psychology classes will serve as Ss. They will be randomly assigned to the five learning groups and members of each group will then be randomly assigned to the six sequences of the stress performance conditions. However, the random assignment will be subject to the qualification that one-half of the Ss in each group (or order) are males and one-half are females.

Apparatus.--A photoelectric pursuit rotor (Model 2203F, Lafayette Instrument Co.) will be used for the tracking task. A .75 inch by .75 inch illuminated target will rotate clockwise at 30 RPM on a circular path with a 10 7/8 inch diameter (center of path). The target will be tracked using a rigid stylus (containing a photoelectric cell) whose aperture in the tip is 1/8 inch. The photoelectric cell sensitivity will be set so that an "on target" will be registered when the center of the stylus aperture passes over the edge of the target. The target surface of the rotor will be 36 inches above the floor. The S's time on target will be recorded by a .01 second timer (Lafayette Instrument Co., Model 20225AD.) and the number of errors will be recorded by means of an impulse counter (Lafayette Instrument Co., Model 5707A) capable of counting 600 pulses per minute.

Each trial period and intertrial interval will be automatically controlled by a repeat cycle timer (Lafayette Instrument Co., Model 1). The interval during rest and instruction periods will be timed by a stop watch.

Electric shock will be administered by means of an inductorium (Physiological Electronics, Inc., Model 3901). A high frequency spiked shock is emitted which maximizes discomfort but maintains a large safety factor. The unit operates with two D size batteries and can be operated by remote control.

A Voice of Music tape recorder (Model 722) will be used to record a signal which will coincide with the frequency and duration of "off-target" on the pursuit rotor under task-related stress during the learning period. This recorded signal will then be used to operate an electronically controlled relay which will regulate the frequency and duration of electric shock during the task-unrelated stress condition.

A Recording GSR Apparatus (Marietta Apparatus Co., Model 12-13R) will be used to indicate a S's skin resistance level and changes which take place in the resistance level. The S's resistance is one leg of a bridge circuit (D.C.) and a balance control is the other leg. All resistances from 0 to 200,000 ohms may be balanced. In the

A.C. mode of operation, the percent of change of total resistance from 0 through 500,000 ohms can be read and the unit will automatically center in the mode. Changes of resistance from 10% to 100% may be recorded by setting the sensitivity control at the desired level. The unit also contains an event marker. Chart speed is 4 inches per minute. Silver impregnated loop and pile nylon finger electrodes will be used. The electrode currect remains constant at 10 microamperes.

Procedure.--Each S will undergo the appropriate experimental conditions individually and the total session for each S will last approximately 45 minutes. S's appointments will be made at the convenience of the S and the experimenter with the exception that Ss serving in the learning task-related condition will be scheduled prior to their paired S in the learning task-unrelated conditions. (See description of task-unrelated stress below.)

Upon reporting for the experiment, each S will be presented the following general explanation of the study.

> I am studying some of the conditions which affect the human abilities involved in guiding and tracking situations. The ability to track or to guide is involved in such activities as keeping an automobile on the road, flying an airplane, leading a duck or quail when hunting, sewing a seam on a sewing machine, and many other everyday activities. Since most everyday activities are too complicated to study, we have to use less complicated tasks. The task you will be performing involves following a moving illuminated target with a stylus or pointer.
>
> In everyday life we frequently must carry out activities when muscular tension is present. Therefore some of the time while you are following the target you will receive mild electric shock as a means of inducing muscular tension. Through this I hope to learn something about how people react to increased muscular tension while guiding or tracking.

Immediately following the general instruction, the GSR electrodes will be attached to the S's forefinger and ring finger of his non-preferred hand. Although one may operationally use electric shock as a stressor, some indication that it serves as a stressor for a S can be valuable. A subjective self-report and/or a physiological measure (as GSR) would allow at least some data from which an evaluation of the effectiveness of the shock as a stressor and may contribute to the understanding of any individual S's reactions which seem to deviate appreciably from the general reaction pattern of other Ss. The following instructions will be used with each S.

> Are you right-handed or left-handed?
>
> I am going to attach these two electrodes to your fingers to get an idea of the amount of tension in your muscles. When tension increases in your muscles your cells give off a greater electrical potential and this can be picked up and measured.
>
> You will not receive any shock through these electrodes. (Electrodes are attached.) Now is that comfortable? Just let your arm hang at your side naturally with your fingers extended like this (Demonstrate).

Next, the shock electrodes will be attached to the S's ankle. Following placement of the electrodes, the level of unpleasant shock to be used later in the experiment will be determined. The highest of the three determinations will be used. The purpose of determining a crude threshold is merely to introduce the S to the measurement procedure. The following instructions will be used.

> Now we are ready to place the shock electrodes on your ankle. I will always tell you ahead of the time before any shock will occur. You will always know when you can expect the shock. (Attach electrodes)
>
> Now we are ready to adjust the level of shock so that it will be suitable for you. I will turn on the shock apparatus but you will not feel anything. Then I will gradually increase its strength until you tell

me you can just barely feel it. Alright? I am turning it on. ON! Do you feel anything now? I'll increase it a little more. Tell me when you first feel a slight shock or tingling sensation. (Record response level.)

Now let's start again. The shock is turned down again. Tell me when you first feel a slight shock or tingling sensation. (Record response level.)

Now I will increase the level of shock gradually. I want you to tell me when the shock is unpleasant and uncomfortable but not painful. We want to find the level where the shock is unpleasant and uncomfortable. We do not want it to reach a painful level. OK? Now, tell me when the shock becomes unpleasant and uncomfortable. (Increase shock gradually, stop at sign from subject, decrease level to about threshold level.) (Record.) Now tell me again when the shock becomes unpleasant and uncomfortable. (Decrease level as before, record.) One more time. Tell me again when the shock becomes unpleasant and uncomfortable. Fine. (Decrease and turn off. Record.) That is all for now. (Detach wires to one electrode.) We will leave the electrodes on but will disconnect a wire so you won't receive a shock accidentally.

The task to be performed by all Ss will be to track with a stylus an illuminated target rotating on a circular path at 30 RPM. A trial will consist of a 30 second period of tracking. Each trial will be followed by a 15 second rest interval with 1 minute periods when further instructions are to be given. Two types of measures will be recorded for each trial: time on target (to the nearest .01 second) and number of errors (one-half or more of the stylus aperture being off the illuminated target). The following instructions will be used.

Let me show you the tracking task and how to do it. This gadget is called a photoelectric pursuit rotor. The idea is to take this stylus in your hand (Demonstrate) and follow the illuminated moving target like this (Demonstrate). Let the stylus glide lightly on the glass surface. Do you understand what to do? Just follow the moving target with the stylus. Try to keep the stylus in the middle of the target as it moves.

Each trial will last for 30 seconds and will be followed by a 15 second rest period. You will track the target for 30 seconds while it is moving. At the end of the 30

> seconds the target will stop. Let your arm relax and rest during the 15 second rest period. I will say "Ready" just before each trial. Now let's do three trials for practice to be sure you understand what to do. Remember! Stay on the target as much as possible. Ready, track as soon as the target moves.

The remainder of the experiment is divided into two parts; the learning period and the stress performance period.

During the learning period Ss will undergo conditions according to the schedule (See Table 1) for the group to which they were randomly assigned.

A one minute rest period will follow trials 3, 12, and 21 in order that appropriate stress instructions may be given.

The specific stressor to be used in the present experiment is electric shock. Electric shock will be used so that the results may be related to other studies making use of this type of stressor. In addition, electric shock can be conveniently controlled and administered in relation to the type of task and stress conditions of the study.

Task-related stress (RS) will refer to the condition arranged so that a S may avoid the electric shock by tracking accurately but will receive the electric shock when he is off the target.

Task-unrelated stress (US) will involve a condition in which a S will receive electric shock whether or not he is tracking accurately. A continuous record will be made of the frequency and duration of the shock administered to each S in the RS conditions. The same sequence of shock will be administered in the US conditions to Ss randomly paired according to the same sex and subgroup (early, late). In this manner, the frequency and duration of shock administered with the RS and the US conditions will be equated.

The instructions for the three stress conditions are as follows:

> No stress: For the next few trials you will track the target (a) as you have been doing, (b) without receiving any shock. (Disconnect shock wire.) Remember! Stay on the target as much as possible.
>
> Task-related stress: On the following few trials you will receive a shock whenever you are not tracking the target accurately. (Connect shock wire.) As long as you keep the stylus over the moving target you will not receive any shock. But whenever the stylus is off the moving target you will receive an electric shock. The shock will be at the level you indicated earlier as unpleasant and uncomfortable. Remember! Stay on the target as much as possible.
>
> Task-unrelated stress: During the next few trials you will receive a series of shocks. (Connect the wire.) The frequency and duration of the shocks is predetermined so there is nothing you can do to cause or to avoid them. They will occur whether you are tracking the moving target accurately or inaccurately. The shock will be at the level you indicated earlier as unpleasant and uncomfortable. Remember! Stay on the target as much as possible.

Following this first part of the investigation, the learning period, an interval of one minute rest will occur during which appropriate instructions will be given.

In the second part, the stress performance period, each S will perform the tracking task under each of three stress conditions, RS, US, and TS. One male and one female from each of the five learning groups will randomly be assigned to each of the six possible sequences of the three stress conditions. (See Table 2)

A one minute instruction and rest period will occur between each stress condition. Three trials will be given for each stress condition. Instructions for the RS and for the US conditions will be the same as those used previously, during the learning period. Instructions for

TABLE 2

Sequence of Stress Conditions

Sequence	Order		
No.	1st	2nd	3rd
1	RS	US	TS
2	RS	TS	US
3	US	RS	TS
4	US	TS	RS
5	TS	RS	US
6	TS	US	RS

RS - Task-related stress
US - Task-unrelated stress
TS - Threat stress

the TS are as follows.

> Threat-stress: Next you will have another block of 3 trials without any shock. After the 3 trials on the pursuit rotor we will finish our calibration of the shock by increasing it as high as you can possibly stand. We will run it up to where it is painful and you can't take it any higher. Right now though, these next three trials are without any shock. Remember! Stay on the target as much as possible.
>
> (After the three trials)
>
> I'm sorry, I made a mistake. We don't need to calibrate the shock again.
>
> A. (For those whose threat is last in the sequence.) That finishes all the trials and shock sessions.
>
> B. (For those who still have RS or US yet.) We just use the unpleasant level we determined earlier. (Then RS or US instructions as appropriate.)

TS will involve the S's performance when no electric shock will be delivered. However, the Ss will expect a determination of the maximum amount of shock they can stand immediately following the task performance.

The US (frequency and duration of shocks) for the three trials will be the same for all Ss. One male and one female preliminary S will proceed through trials 1 through 24 and then perform three trials under RS conditions. The frequency and duration of shocks for the male and for the female will then be used for all other like-sexed Ss under the US condition. (Data from these two preliminary Ss will not be used except to determine the US to be used.)

Upon completion of the final trial, the GSR and shock electrodes will be removed and the skin cleaned of electrode paste. The S will be thanked for participating and will be asked not to discuss the study with anyone. If he wishes to learn the final results of the study, arrangements will be made to provide him with this information.

Experimental design.--A mixed type of design will be used which involves repeated measurements on several independent groups. A schematic representation of the general design is presented in Figure 6.

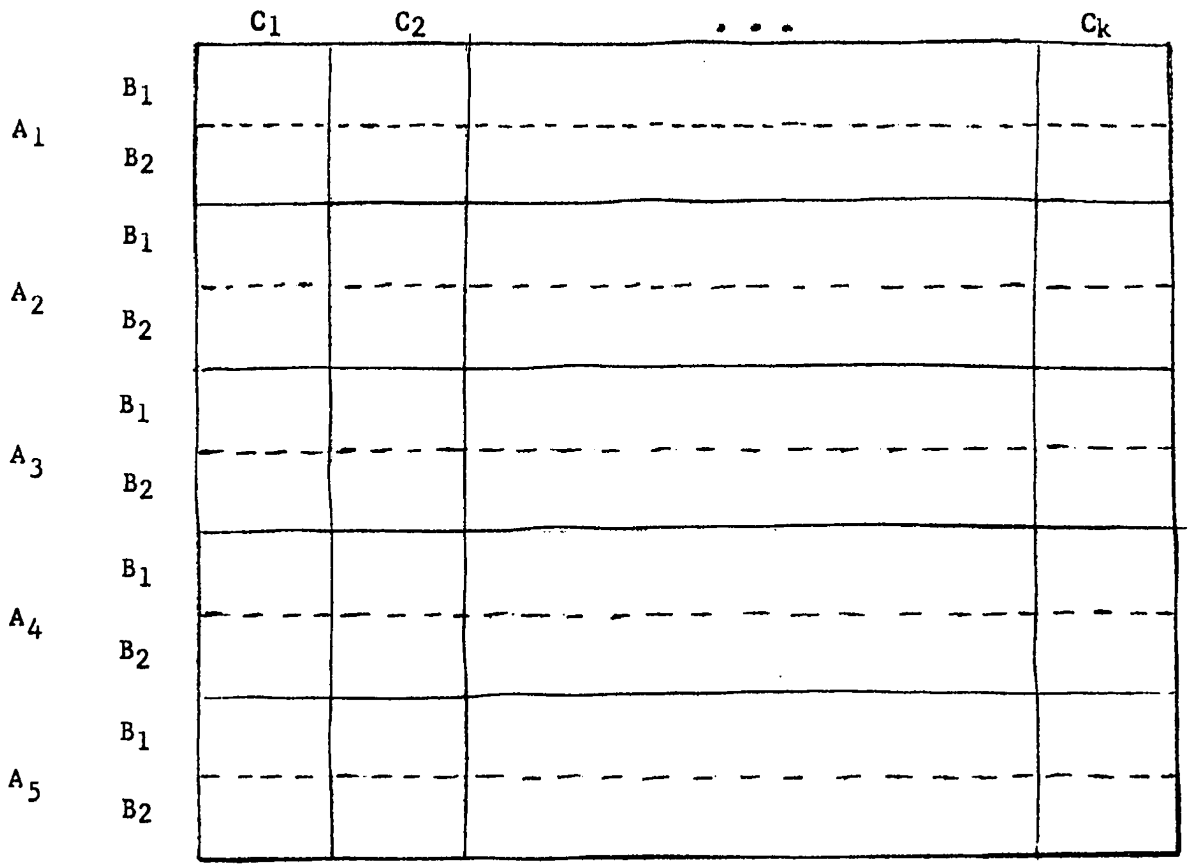
The sixty Ss will be randomly assigned to each of five groups with the restriction that six males and six females be placed in each group.

All five groups will track under no-stress during the first block of trials. This will provide a base performance from which learning of the task can be inferred and any differential effects due to the stress conditions can be assessed.

The five groups will undergo different conditions during the learning period of the experiment. The NS group will experience NS during the learning phase (blocks 2-7) and will serve essentially as a control group. Two RS groups will be used: one group will receive RS during the early blocks (2-4) of trials and the other group will receive RS during the late block (5-7) of trials. Two US groups will be used: one group will experience US during the early blocks (2-4) of trials and the other group will receive US during the late blocks (5-7) of trials.

All five groups will then perform the tracking task under a NS condition (block 8). Differences in learning associated with the type of stress or with the time stress is introduced can then be evaluated. An indication of whether the stress conditions affect performance or learning can be attained.

One male and one female from each group will be randomly assigned



Factor A: Independent Random Groups

A_1 No stress
A_2 Early task-related stress
A_3 Late task-related stress
A_4 Early task-unrelated stress
A_5 Late task-unrelated stress

Factor B: Sex

B_1 Male
B_2 Female

Factor C: Repeated Measures (Learning Period)

C_1-C_8 Successive blocks of 3 trials
or
(Type of stress)

C_1 Task-related stress
C_2 Task-unrelated stress
C_3 Threat-stress

Figure 6. A schematic representation of the research design.

to each sequence of the stress conditions. Each subject will track under all three types of stress (RS, US, and TS) conditions but in his assigned sequence. Thus all possible sequences will occur within each group.

Statistical analysis.--Several analyses will be made. Two analyses will be based on data from the learning period and two on data from the stress-performance period. Other analyses will be based on data from subjective reports and GSR data.

Analysis of data for the learning period and the stress-performance period will be conducted for the split-plot factorial designs with two between-block treatments and one within-block treatment (Kirk, 1968). A summary of the analysis may be seen by reference to Table 3.

TABLE 3

Summary of Analysis of Variance

Source	SS	*df*[a]	*df*[b]	MS	F
Between subjects					
1 A	...	4	4	...	1/4
2 B	...	1	1	...	2/4
3 A X B	...	4	4	...	3/4
4 Subjects within groups	...	50	50	...	
Within subjects					
5 C	...	7	2	...	5/9
6 A X C	...	28	8	...	6/9
7 B X C	...	7	2	...	7/9
8 A X B X C	...	28	8	...	8/9
9 C X Subjects within groups	...	350	100	...	

(a) Degrees of freedom for learning period data.

(b) Degrees of freedom for stress performance period data.

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APPENDIX II

TABLES

TABLE 4

Summary of Analysis of Variance for
Time on Target During Learning Period

Source	df	MS	F
Between subjects			
Stress group (A)	4	226.08	2.06
Sex (B)	1	795.57	7.27**
A X B	4	247.05	2.26
Subjects within groups	50	109.48	
Within Subjects			
Trials (C)	7 (1)[a]	92.93	24.20**
A X C	28 (4)[a]	5.98	1.56
B X C	7 (1)[a]	1.76	.46
A X B X C	28 (1)[a]	4.13	1.08
C X Subjects within groups	350 (50)[a]	3.84	

**$p < .01$

(a) Modified degrees of freedom used for the conservative tests of significance.

TABLE 5

Summary of Analysis of Variance
for Errors During Learning Period

Source	df	MS	F
Between subjects			
Stress group (A)	4	1677.15	2.29
Sex (B)	1	7059.47	9.63**
A X B	4	653.99	.89
Subjects within groups	50	732.99	
Within subjects			
Trials (C)	7 (1)[a]	235.54	9.20**
A X C	28 (4)[a]	29.14	1.14
B X C	7 (1)[a]	57.76	2.26
A X B X C	28 (4)[a]	19.53	.76
C X Subjects within groups	350 (50)[a]	25.59	

**$p < .01$

(a) Modified degrees of freedom used for the conservative tests of significance.

TABLE 6

Summary of Time on Target Trial Means, Standard Deviations and Differences Between Means During Learning Period

Difference between trial means[a]								$\bar{X}$	SD
Trial	2	3	4	5	6	7	8		
1	2.08**	1.77**	1.62**	3.51**	2.75**	2.34**	4.04**	18.68	5.05
2		- .31	- .46	1.43**	.67	.21	1.96**	20.76	4.78
3			- .15	1.74**	.98	.57	2.27**	20.45	4.72
4				1.89**	1.13*	.72	2.42**	20.30	4.64
5					- .76	-1.17	.53	22.19	4.26
6						- .41	1.29	21.43	4.14
7							-1.70	21.82	4.35
8								22.72	4.44

* $p < .05$ ** $p < .01$

(a) Differences represent Trial 2-Trial 1, etc. The significance of differences was determined by Dunn's multiple comparison procedure.

TABLE 7

Summary of Error Trial Means, Standard Deviations
and Differences Between Means During Learning Period

	Difference between trial means[a]							$\bar{X}$	SD
Trial	2	3	4	5	6	7	8		
1	.9	1.8	1.8	4.0**	3.6**	3.0*	6.3**	38.0	9.90
2		.9	.9	3.1*	2.7	2.1	5.4**	37.1	12.09
3			.0	2.2	1.8	1.2	4.5**	36.2	11.69
4				2.2	1.8	1.2	4.5**	36.2	11.60
5					- .4	- .10	2.3	34.0	12.72
6						- .6	2.7	34.4	11.44
7							3.3**	35.0	11.62
8								31.7	11.72

* $p < .05$ ** $p < .01$

(a) Differences represent Trial 1-Trial 2, etc. The significance of differences was determined by Dunn's multiple comparison procedure.

TABLE 8

Summary of Analysis of Variance for Time on Target During Stress Conditions

Source	df	MS	F
Between subjects			
Stress group (A)	4	59.02	1.42
Sex (B)	1	239.27	5.78*
A X B	4	81.54	1.97
Subjects within groups	50	41.43	
Within subjects			
Stress Conditions (C)	2 (1)[a]	4.18	16.72**
A X C	8 (4)[a]	6.08	24.32**
B X C	2 (1)[a]	.12	.48
A X B X C	8 (4)[a]	20.68	82.72**
C X Subjects within groups	100 (50)[a]	.25	

* $p < .05$ ** $p < .01$

(a) Modified degrees of freedom used for the conservative tests of significance.

TABLE 9

Summary of Analysis of Variance
for Errors During Stress Conditions

Source	df	MS	F
Between subjects			
Stress group (A)	4	621.42	2.42
Sex (B)	1	3419.99	13.33**
A X B	4	389.56	1.52
Subjects within groups	50	256.47	
Within subjects			
Stress conditions (C)	2 (1)[a]	100.62	6.23*
A X C	8 (4)[a]	30.42	1.88
B X C	2 (1)[a]	26.12	1.62
A X B X C	8 (4)[a]	18.10	1.12
C X Subjects within groups	100 (50)[a]	16.14	

* $p < .05$ ** $p < .01$

(a) Modified degrees of freedom used for the conservative tests of significance.

TABLE 10

Summary of Time on Target Difference
Between Means of Stress Conditions for each Stress Group

Stress group	Difference between stress conditions[a]		
	RS-US	RS-TS	US-TS
NS	- .27	- .80**	- .53*
ERS	- .42	.20	.62**
LRS	- .22	1.26**	-1.04**
EUS	1.66**	1.65**	- .01
LUS	1.68**	.55*	-1.33**

* $p < .05$ ** $p < .01$

(a) The significance of differences was determined by Dunn's multiple comparison procedure.