N-96-01
II-A-49

EPA-600/1-77-038
June 1977

Environmental Health Effects Research Series

BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF VARYING NOISE ENVIRONMENTS

Office of Health and Ecological Effects
Office of Research and Development
U.S. Environmental Protection Agency
Washington, D.C. 20460

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ENVIRONMENTAL HEALTH EFFECTS RESEARCH series. This series describes projects and studies relating to the tolerances of man for unhealthful substances or conditions. This work is generally assessed from a medical viewpoint, including physiological or psychological studies. In addition to toxicology and other medical specialities, study areas include biomedical instrumentation and health research techniques utilizing animals — but always with intended application to human health measures.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

EPA-600/1-77-038
June 1977

BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF VARYING NOISE ENVIRONMENTS

by

Lawrence F. Sharp
John F. Swiney
Mickey R. Dansby
Stephen C. Hyatt
Dale E. Schimmel
Department of Behavioral Sciences and Leadership
United States Air Force Academy, Colorado 80840

Contract No. IAG-D4-0537

Project Officer

George R. Simon
Health Effects Division
Office of Health and Ecological Effects
Washington, DC 20460

OFFICE OF HEALTH AND ECOLOGICAL EFFECTS
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

DISCLAIMER

This report has been reviewed by the Office of Health and Ecological Effects, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendations for use.

ABSTRACT

Eighty male college juniors and seniors were dichotomized into either High or Low Anxiety groups. Each subject experienced a household noise profile under a quiet (50 dBA), intermittent (84 dBA) and continuous (84 dBA) noise condition, while performing either an easy or difficult pursuit tracking task. Heart rate, electromyographic potentials, and tracking error responses were evaluated. Results indicated significant ($P<.01$) main effects for task difficulty and noise condition and significant ($P<.01$) interaction effects for task difficulty, noise condition and anxiety level (as measured by the IPAT Self Analysis Form) of subjects. The significant noise effect occurred for the difficult task condition during the second tracking period (which includes transfer of training effects) indicating that factors such as task difficulty, direction of task transfer effects, duration of noise exposure as well as anxiety level of subjects appear to be important variables affecting human psychomotor performance in noise environments below 85 dBA. These findings appear to be consistent with previous research which suggests that task difficulty is the variable determining the direction of stress (noise) effects on psychomotor performance and the nature of the interaction between stress and anxiety level. The present findings are therefore seen as supporting the concepts of the response interference hypothesis and the inverted-U function between stress and performance.

CONTENTS

FIGURES

TABLES

TABLES (continued)

ACKNOWLEDGMENTS

This research was funded by the United States Environmental Protection Agency, Health Effects Division, under EPA-IAG-D4-0537 and EPA-IAG-D5-0537.

The views expressed in this paper represent those of the authors and do not necessarily reflect the views of the United States Air Force or the Department of Defense.

In conduct of this research the authors wish to acknowledge the administrative and technical assistance of Mrs. Berthe Giroux, Mrs. Kathy Rockefeller, Dr. Karl Kryter, Valentin W. Tirman, Stephen Stitch, Bryon Russell and Mark O'Green.

SECTION I

CONCLUSIONS

The experimental results indicate that the relationship between physiological and motor skill variables when noise is used in combination with other variables is extremely complex. In this experiment, there were no significant physiological response differences in electromyographic potential or heart rate changes as a function of either noise profile, anxiety condition, or task difficulty. Previous studies of physiological response to noise stress show similarly conflicting findings. There appears to be an overlap of anxiety and stress in the physiological area and in the awareness of pressure and tension with the result that the degree of familiarity of the stimulus, and the tendency of individual differences to cancel each other out must be taken into consideration before attempting to make significant practical predictions concerning the effects of moderate noise levels on human physiological response.

Anticipation of noxious stimulations also appears to be an important factor in predicting physiological stress reactions to noxious stimulation. Research (Speilburger, 1972) shows that most of the autonomic stress reaction may take place prior to the administration of the noxious stimulation. With time to appraise the situation, subjects are able to develop self-assuring coping responses which can lead to lowered physiological activation during the experimental period. This factor may have contributed to the lack of practical significance between baseline and experimental condition physiological arousal levels in the present experiment. In summary, human physiological response to moderate environmental noise is a complexly controlled system and may not be a reliable indicator of arousal level and stress at noise levels below 85 dBA.

The average performance of each subject on the Stroop Chart reading task improved as a result of the experimental conditions reflecting the arousing but not debilitating effect of the experiment. Previous noise research which dealt with high (115 dBA) sound pressure levels have shown decrements in

Stroop Chart reading times. Apparently, 84 dBA noise levels are not debilitative on this task. Instead, the data reflect that merely being in a controlled environment, or attending, independent of noise condition, to a demanding task could have produced the improvement in reading times.

In terms of psychomotor performance, task difficulty, anxiety level, and noise condition all interacted to determine tracking error with the result that the poorest tracking performance occurred when high anxiety subjects were required to switch from the easy to the difficult task during exposure to intermittent noise. Overall, the best tracking performance occurred when high anxiety subjects performed the easy tracking task, regardless of noise condition and task transfer direction. Tracking performance on the difficult task, however, improved significantly when low anxiety subjects were exposed to noise and also when high anxiety subjects were not exposed to noise. Apparently, moderate intensity (84 dBA) household noise serves as a stressor for high anxiety subjects and as a facilitator for low anxiety subjects performing a difficult psychomotor task.

The interaction between noise condition and anxiety level occurred only during the second five minute tracking/noise exposure period (data 2) when the task was difficult, which suggests that duration of stress (noise and tracking) as well as task transfer effects are important variables in moderate level (below 85 dBA) noise research.

These findings appear to be consistent with previous research which suggests that task difficulty is the variable determining the direction of stress (noise) effects on psychomotor performance and the nature of the interaction between stress and anxiety level. The present findings are therefore seen as supporting the concepts of the response interference hypothesis and the inverted-U function between stress and performance. Anxiety then, as a personality variable, when predicting the effects of moderate noise on psychomotor performance, should be evaluated as a probable determinant of moderate noise effects on human behavior.

In summary, moderate intensity, (84 dBA) household noise, appears to act as a stressor for high anxiety subjects performing a difficult psychomotor task and particularly for those who experience noise as: 1) primary overstimulation, i.e., feelings of being overwhelmed and bombarded with stimuli; 2) or who lack an appropriate course of action to resolve undirected arousal, anxiety and frustration as a result of unavoidable noise exposure; 3) a violation of expectancies; 4) or where noise serves to interrupt cognitive processes resulting in the inability to carry out a cognitive plan when experiencing interruption or environmental disorganization due to noise exposure. Consequently, it may be that one of the primary effects of moderate environmental noise is its interrupting, disorganizing quality, which would be particularly debilitating to those subjects who already experience substantial internal arousal as the result of elevated trait anxiety levels. In conclusion, except for that segment of the population that could be characterized as possessing low trait anxiety and who actually appear to profit (at least temporarily) from moderate noise stimulation on difficult psychomotor tasks, or for high and low anxiety subjects on easy psychomotor tasks, by adding stimulation from the environment (noise) that violates or precludes the development of expectancies (intermittent noise), it can then be expected that decrements in psychomotor performance will probably occur on difficult psychomotor tasks, and as part of the "cost" to the person, frustration can also be expected to occur with its special relevance for maladaptive behavior and the normal stresses of everyday living that now appear to plague our highly industrialized, urban society.

SECTION II

RECOMMENDATIONS

The results of this study suggest that future research investigating the physiological effects of stress due to broadband noise below 85 dBA should consider employing measures other than average heart rate and electromyographic potentials from which to predict human physiological response. Additionally, attention should be focused on the degree to which subjects have achieved physiological baseline prior to noise exposure.

The results also suggest that the internal arousal level of subjects (anxiety) is an important variable although a more heterogeneous subject population may have resulted in an even larger effect due to the anxiety variable. In this regard, factors such as task difficulty, direction of task transfer effects and duration of noise exposure appear to be important variables requiring careful consideration when predicting the interaction of previous arousal level (anxiety) and stress (moderate noise) on psychomotor performance.

Due to subject unavailability, sex differences were not evaluated in the present study. Future research should attempt to determine if such differences exist, and the applicability of the present findings should be experimentally expanded to include a cross section of the general population performing psychomotor tasks that are representative of the work activities experienced by that population.

Finally, in practical terms, even though the independent variables in the present study resulted in significant mean differences in psychomotor performance, only a small proportion (19%) of the total variance in tracking performance has been accounted for. This would indicate that individual differences as well as other factors have not been fully explored and, therefore, substantially limit the applicability of these findings to similar subject populations.

SECTION III
INTRODUCTION

The 1973 International Congress on noise as a public health problem, especially the psychological consequences, began with a rather somber summary. Gulian (1973) noted that most noise research since the 1950s is generally controversial and no firm conclusions can be drawn. Gulian attributes the disparate research results to the extraordinary complexity of factors which intenvene between noise as the independent variable and the dependent measures. Even a cursory examination of the literature during the past five years dramatically substantiates this complexity and the paucity of variables involved. For example, some researchers have found noise induced facilitation of learning and cognitive performance (Fechter 1972) while others observe a decrement (Renshaw, 1973). Others have found sex (Kumar, 1969 and Elliott, 1971) age (Mathur, 1972) and social class (Anderson, 1973) differences in response to noise. To further complicate interpretation of the findings, Harcum and Monti (1973) found that subjects will "cooperate" with the experimenter on noise disturbance ratings unless this factor is controlled. Although much research seems to confirm the absence of the main effects for noise alone, some research is beginning to emerge which shows the interactive nature of noise as an independent variable. For example, Harris and Schoenberger (1970) demonstrated that the detrimental effect of noise is additive to that of vibration when both are presented simultaneously. When combined with noise, the additional stressor of shock (using rodents) (Campbell, 1968) and neomycin (Jauhiainen, Kohonen and Jauhiainen, 1972) produce a synergistic effect. Indicative of the problems associated with these research findings are Grether's (1972) research which failed to demonstrate combined effects of heat, noise and vibration and Kryter's (1970) caution when using rodents and rabbits as subjects in noise research.

The data on threshold shift (temporary or permanent) and hearing loss is certainly well founded, especially for extreme noise environments, and with appropiate protective apparatus, damage can be attenuated or avoided. There seems to be a lack of appreciation however, for the effect of moderate noise environments and for the effects these environments have on non-auditory or non-physiological responses. Recent research by Bull (1973), Edsell (1973) and Glass and Singer (1973) provide good evidence that even "low" (84 dB) noise environments result in important changes in socially relevant behavior; e.g., tolerance for ambiguity decreases in a noise environment (Bull, 1973); perception of others assumes negative dimensions (Edsell, 1973); and frustration tolerance decreases (Glass and Singer, 1973). These effects obviously represent the psychological cost the organism pays for exposure to unavoidable environmental noise. In fact, behavioral responses to noise and behavioral differences between subjects may be among the most important indicants of noise effects and a major source of variation in the various dependent measures assessed.

Some recent studies of noise and personality have focused on introversion or extroversion as contributors to psychomotor performance differences under noise conditions. These studies have been generated by Eysenck's theory of personality and cortical arousal. In general, extroverts were found to display greater decrements in psychomotor performance while experiencing noise stimulation than were introverts. Di Scipio (1971) showed that white noise facilitates psychomotor response for an optimal period of time, after which decrements were observed. This effect was heightened for extroverts. Even though extroverts are more prone to noise distraction, Elliott (1971) showed that they will tolerate greater intensities of white noise than will introverts. Results of other studies on noise and social behavior are diverse. Edsell (1973), indicates that subjects in a game situation perceived other players as more disagreeable, disorganized, and threatening under noise as opposed to no-noise conditions. Jansen & Hoffman (1971) demonstrated that increasing the loudness of a noise stimulus augmented subjective annoyance, with neurotic personality tendencies contributing to this effect. Angrier speakers were found to use more high frequency elements in their speech (Mason 1969).

Stephens (1970) showed that test anxiety scores correlated positively with the slope of a loudness judgement function.

The above considerations and the data to be presented in this paper readily attest to the fact that the main effects of noise, especially moderate levels (60-90 dB) are elusive, depend to some extent on the psychological structure of the recipient, and, potentially, can be confounded with a seemingly endless array of other factors.

The research reported in the paper was conceived and conducted to: (1) specifically assess a noise profile to which a large proportion of both urban and suburban dwellers are exposed on a daily basis; (2) examine these effects on a relatively homogenous population with respect to sex, age, physical fitness, intellectual ability, psychological structure, and environmental stress; and (3) provide more adequate control in terms of research design, of individual differences which could potentially contribute to between group differences in noise responses.

SECTION IV
METHOD

SUBJECTS

Eighty male junior and senior Air Force Academy cadets provided data for this study. Subjects were volunteers, solicited from upper division Behavioral Science and Life Science classes. No inducements were offered. Eighty subjects initially agreed to participate and completed "Informed Consent" certificates in accordance with HEW standards.

Participating subjects were administered an anxiety scale to assess their relative levels of state-trait anxiety. On the basis of this measure, subjects were dichotomized as above (High Anxiety) or below (Low Anxiety) the group median score. Each subject was then randomly assigned to one of the four task sequence groups, which resulted initially in eight cells of ten subjects each. Figure 1 displays the frequency distribution of anxiety measure scores of the experimental sample versus national, male college norms. These distributions differed significantly ($\chi^2 = 25.81$, $df = 9$, $p < .005$) and the group mean, STEN scores were significantly different ($t = -10.88$, $df = 40$, $p < .005$).

DESIGN

A 2 x 3 x 4 factoral design was employed. Table 1 shows the variables and levels involved.

Forty subjects served under each of the two anxiety conditions. Within each anxiety condition, ten subjects served under each of the four task sequence conditions. Each cell of ten subjects experienced the three noise conditions in a counterbalanced, repeated measures sequence.

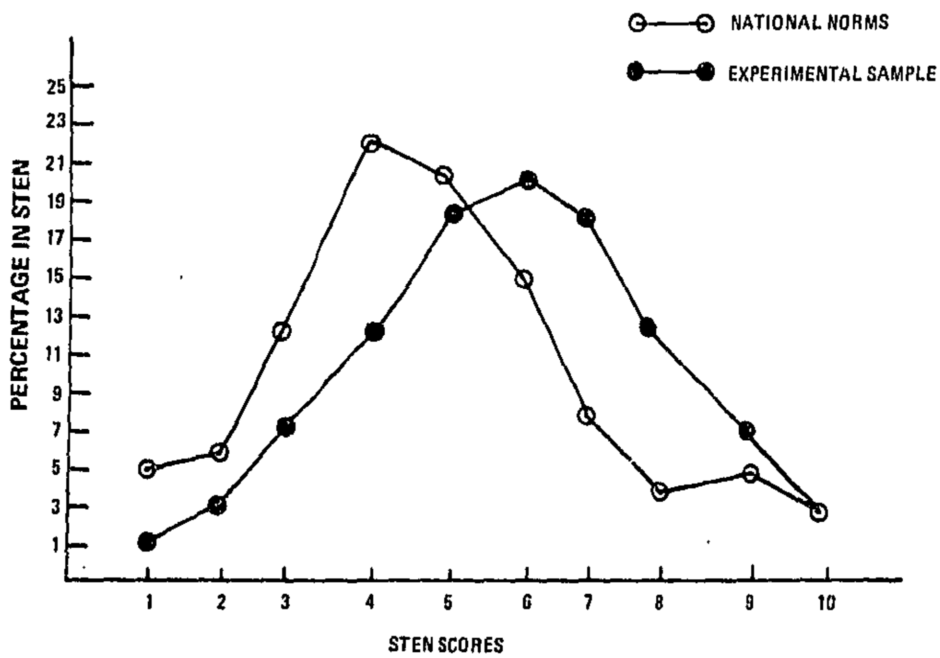


FIGURE 1. STEN SCORES OF EXPERIMENTAL SAMPLE AND NATIONAL COLLEGE SAMPLE.

TABLE – 1. EXPERIMENTAL DESIGN

	HI ANXIETY			LO ANXIETY		
	Q[a]	IN	CN	Q	IN	CN
EASY TO EASY[b]	S 1 THRU S 10	→	→	S 41 THRU S 50	→	→
EASY TO DIFFICULT	S 11 THRU S 20	→	→	S 51 THRU S 60	→	→
DIFFICULT TO EASY	S 21 THRU S 30	→	→	S 61 THRU S 70	→	→
DIFFICULT TO DIFFICULT	S 31 THRU S 40	→	→	S 71 THRU S 80	→	→

[a]Q = QUIET CONDITION (50 dBA MASK)
IN = INTERMITTENT PROFILE
CN = CONTINUOUS PROFILE

[b]REFERS TO DIFFICULTY LEVEL OF TWO, SUCCESSIVE, 5 MINUTE TRACKING TASKS, ACCOMPLISHED UNDER EACH NOISE CONDITION.

APPARATUS

The experimental sessions were conducted in the Behavioral Sciences Laboratory at the United States Air Force Academy. A controlled acoustic environment was provided through the use of ventilated, Industrial Acoustics (AIC) audiometric examination booths. Each chamber was equipped with a Hewlett Packard 1205A dual trace oscilloscope which displayed a randomly moving, horizontal "target" line as well as the subject's "controlled" line. A 60 Hz sign-wave was superimposed on the controlled line to aid in subject differentiation between the two lines. Total system inputs and outputs are shown by block diagram in appendicies 1 and 2 respectively.

A Weston 1242 digital multimeter was located on top of each oscilloscope, adjusted to display (-10 to +10) volts, and represented real-time integrated tracking error, which provided immediate feedback to subjects during the training portion of each experimental session.

Subjects sat facing the oscilloscope at an approximate viewing distance of 33 cm. The oscilloscope was placed at eye level to minimize parallex distortion. A Measurement Systems Model 542, 2 axis, gimballed joystick was installed at the end of the subject's right arm rest. Coil springs, set at .45 kg maximum deflection force, were used to return the handle to center. Maximum possible stick deflection was 28° from center in each direction.

The experimental variable, noise, was introduced via a high-fidelity (AR2-ax) bookshelf loudspeaker located immediately above and facing the seated subject. Fifty dBA of background acoustical masking was provided continuously through a "Sound Shield" random noise generator placed adjacent to the loudspeaker. A 2-way intercom station was installed in each chamber as well as the necessary EKG and EMG leads and electrodes.

The audio input was generated by combining signals from a Hewlett-Packard (HP) 8057A Precision Noise Generator set for "pink" noise, and a HP 3722A

Noise Generator with a selective sequence length of N = 15, clock period of 100 ms and gaussian noise bandwidth of .5 Hz with the variable output set for "binary". The generated signal was magnetically recorded on a Crown Model 824SX 4-track tape recorder, the output of which was then 1/3-octave band shaped in real-time by a Bruel and Kjaer (B&K) Model 125 1/3-octave Graphic Frequency Response Equalizer and amplified by a Crown IC-150 preamplifier and DC-300A laboratory amplifier. The audio profile chosen represented 84 dBA of typical suburban household noises and was generated by magnetically recording a central heating system, television program, and a canister type vacuum cleaner at operator ear level in a carpeted and draped living room. A calibrated (± 1 dB 20 - 30 KHz) Crown 824SX tape recorder was used with input provided by a B&K 2619 Microphone Preamplifier, B&K 4133 1/2" Condenser Microphone with a UA 0386 Nose Cone, a B&K 2804 Power Supply and calibrated for absolute Sound Pressure Level (SPL) by a B&K 4220 Pistonphone. Overall SPL was measured by a General Radio (GR) 1558-BP Octave Band Noise Analyzer for both dBA and dBC values. Calibration was performed prior to measurements with a GR Type 1562 Sound Level Calibrator. The resultant magnetic tape was then analyzed using a HP 8064A Real-Time Audio Spectrum Analyzer, the output of which was connected to a HP 7004B X-Y Recorder and automatically plotted on HP 08064-9010 dB scaled graph paper. Primary spectral energy content centered between 200 and 300 Hz with a peak at 400 Hz (see Figure 2).

The final audio profile was verified by real-time 1/3 octave band analysis in the sound chamber at subject ear level. Microphones, equalizers, and amplifiers, etc. were the same items used in the original recording process. Final A-weighted SPL settings were done with a test subject in place and the chamber door closed.

The random tracking signal input was generated by the HP 3722A low frequency random noise generator with a selective sequence length of N = 4,095, clock period of 333 ms and gaussian noise band width of .15 Hz.

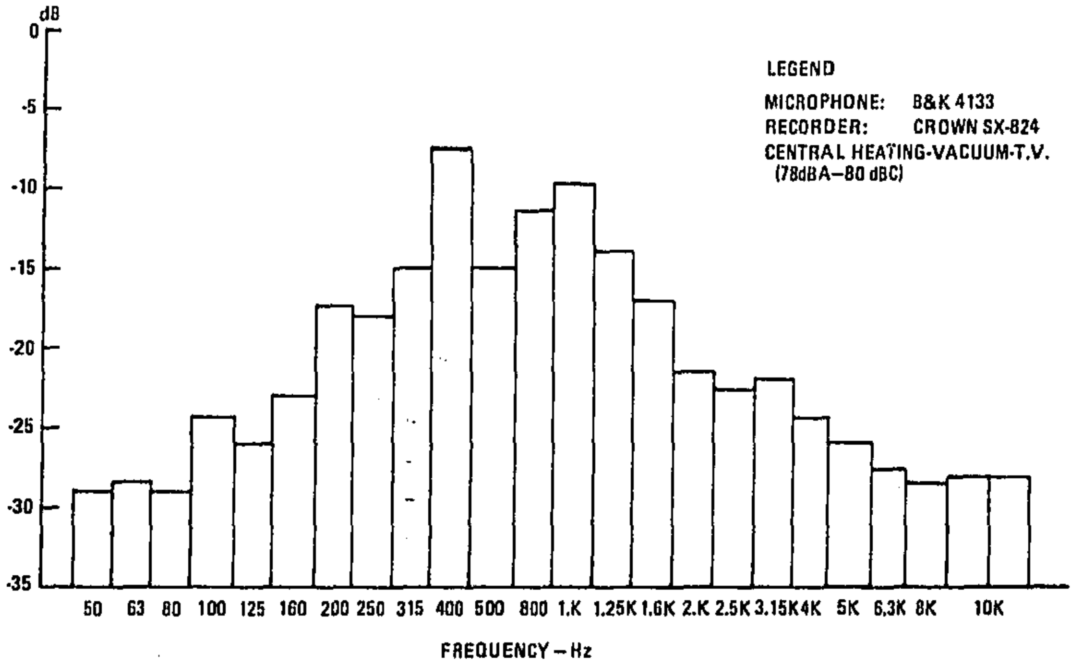


FIGURE 2. 1/3 – OCTAVE BAND SPECTRAL ANALYSIS OF NOISE PROFILE

Subject tracking output and tracking signal input were fed into an EIA TR-20 analog computer which was pre-programmed to present zero order (position control) or first order (rate or velocity) control feedback to the subject and provide an integrated error voltage to drive the digital multimeter display. The analog computer also provided a real-time absolute error voltage output which was magnetically recorded on an Ampex FR-1300 14 channel FM instrumentation recorder.

The EMG (Electromyographic) potentials recorded off the frontalis muscle group, were filtered, rectified and magnetically recorded on the FM recorder. The rectifying/filtering circuit was unique and not readily available in the literature. Figure 3 shows the circuit used.

The electrocardiograph (EKG) signal was processed through a Gould/Brush Model 4307 Biomedical-Tachometer Coupler and magnetically recorded.

A Datametrics SP-425 time code generator was used to differentiate the various experimental conditions and to generate a time track on the FM recorder. The subsequent analog data were processed and digitally analyzed.

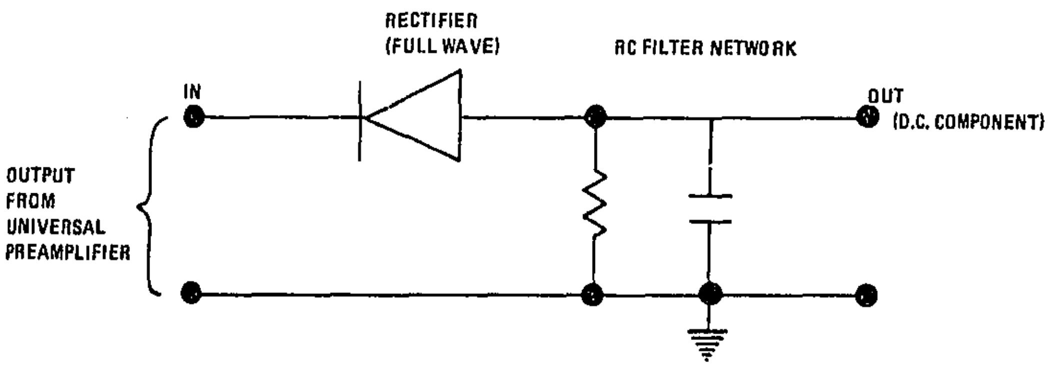


FIGURE 3. SCHEMATIC DIAGRAM OF EMG SIGNAL CONDITIONER CIRCUITRY.

PROCEDURES

Prior to each day's subject runs, complete minimum and maximum calibration voltages were magnetically recorded. A cardiac simulator was used to calibrate heart rate.

After reading and signing an informed consent form, each subject was administered the Institute for Personality Ability Testing "Anxiety Scale Questionnaire", (self-analysis form) a brief, non-stressful, clinically validated questionnaire for appraising free anxiety level.

Results of the test were used to divide the subject pool into statistically significantly different high and low anxiety groups.

Upon entering the experimental room, eye dominance was first assessed, then each subject was randomly administered one of two versions of a standard Stroop Chart "Pretest". Table 2 shows each version of the Stroop Color Word chart. The word in parentheses indicates the color of the associated word.

Time required to successfully complete the chart was then recorded. If the subject made an error, he was instructed to correct the error and continue as quickly as possible.

Normally, two subjects were run simultaneously since two instrumented sound chambers were available. Subjects were instructed to remove their upper body clothing. EKG and EMG electrodes were attached and then the subject seated in the chamber with feet flat on the floor, arm on arm rest, hand on tracking handle, facing the oscilloscope. Subjects were told to relax, and cautioned against extraneous movements of body, head, jaws and random eye movements. Use of the 2-way intercom was explained (it did not require subject manipulation), duration of the experiment was given, and subjects informed that all further instructions would be issued over the speaker located overhead, and that any subsequent questions would be

Table 2. STROOP COLOR WORD CHART ARRANGEMENT[a]

Stroop A			Stroop B		
1-Yellow (orange)	2-Black (green)		1-Green (blue)	2-Red (green)	3-Blue (yellow)
3-Green (blue)	4-Blue (red)	5-Blue (orange)	4-Blue (red)	5-Yellow (orange)	
6-Orange (yellow)	7-Red (green)	8-Blue (orange)	6-Red (blue)	7-Black (green)	8-Blue (red)
9-Yellow (green)	10-Black (orange)		9-Green (orange)	10-Red (yellow)	11-Blue (red)
11-Red) (yellow)	12-Green (blue)	13-Blue (red)	12-Orange (blue)	13-Green (blue)	
14-Yellow (orange)	15-Blue (red)		14-Black (orange)	15-Yellow (green)	
16-Green (blue)	17-Orange (blue)		16-Blue (orange)	17-Red (green)	18-Green (yellow)
18-Green (yellow)	19-Red (blue)	20-Red (green)	19-Orange (yellow)	20-Blue (red)	
21-Green (orange)	22-Blue (red)		21-Green (blue)	22-Yellow (orange)	

[a]It is important to note that both charts were identical except for sequence. The same number of words appeared on each chart, and they appeared in the same colors, but in different orders. For example, the red-colored word BLUE appeared four times on each chart: On chart A it was the 4th, 13th, 15th and 22nd word presented, and on Chart B the 4th, 8th, 11th and 20th word presented.

answered via the intercom.

The chamber door was then closed, and after 2-3 minutes, one minute of physiological data was magnetically recorded (Baseline 1) under the quiet (50 dBA mask) condition. If subjects were scheduled to be exposed to either the continuous or intermittent noise condition, then a second one minute (Baseline 2) of physiological data was recorded with the appropriate noise input.

Two minutes of taped instructions immediately followed. Instructions included the use of the tracking handle, oscilloscope, digital multimeter and the tracking task was explained in detail. A one minute period of questions and answers followed.

Subjects were then exposed to two, 5 minute experimental sessions with a one minute rest period between sessions. These sessions, Data 1 and Data 2 respectively, consisted of exposing the subject to one of three noise conditions; quiet (50 dBA generated by the Sound Shield white noise generator), (2) continuous noise (84 dBA), or (3) intermittent noise (84 dBA) of an identical audio spectrum but randomly cycled, both on and off between one and nine seconds with a total "on" duration of 50% of the five minute experimental session. The identical noise condition used for Data 1 was repeated for Data 2. Each subject was scheduled on a daily basis for three separate experimental sessions, insuring exposure to all three noise conditions and minimizing noise adaptation and fatigue effects.

During each experimental session (Data 1 and Data 2), subjects were required to perform one of two tracking tasks. The task was labeled "easy" (position feedback) or "difficult" (rate or velocity feedback), and the serial presentation of the task was counter balanced (Easy, Easy; Easy-Difficult; Difficult-Easy; and Difficult-Difficult) and remained unchanged during the three experimental sessions for a given subject.

Subjects practiced the tracking task for four minutes with the integrat.' error feedback display on. During the fifth minute, the error display was remotely turned off, and the FM recorder turned on generating the Data 1 and Data 2 information file. Heart rate, EMG level, and absolute tracking error voltages were recorded at this time. The audio signal and time code generator signal were also recorded.

At the completion of Data 2, all recording equipment was turned off, and each subject was immediately administered the Stroop posttest.

To alleviate potential anxiety associated with being exposed to noise and instrumentated with EKG and EMG electrodes, recorded popular music was played prior to and immediately after each experimental session.

SECTION V

RESULTS

ANALYSIS STRATEGY

Multiple analysis of variance for a design involving two between and one, within subject factors was used to assess the significance of the main and interaction effects of the independent variables. This procedure is described in Myers (1972) and provides for analysis of a repeated measurements factor. In this research, each subject served under each of the three noise conditions, hence repeated measurements were made on each subject, for all dependent variables under a quiet, intermittent, and continuous noise environment.

ANALYSIS OF ELECTROMYOGRAPHIC CHANGES

For either Data 1 (First Tracking Task) or Data 2 (Second Tracking Task) none of the independent variables produced significant changes in general muscular tension as evidence by changes in electromyographic potentials taken from the Frontalis Group. Table 3 shows the analysis of variance for these data for the first tracking task (Data 1).

Table 3. ANALYSIS OF VARIANCE FOR THE ELECTROMYOGRAPHIC POTENTIAL DEPENDENT VARIABLE - FIRST TASK

Source of variation	DF	SS	MS	F
Anxiety	1	18.2803	18.2803	2.3989 N.S.
Task difficulty	3	33.9461	11.3154	1.4894 N.S.
Anx x tsk dif	3	44.6793	14.8931	1.9544 N.S.
Error	72	564.5801	7.6200	
Noise condition	2	5.4246	2.7123	.3447 N.S.
Anx x noise cond	2	39.6191	19.8096	2.5182 N.S.
Task dif x noise cond	6	46.5791	7.7632	.9868 N.S.
Anx x tsk dif x noise condition	144	1132.7677	7.8664	
Total	239	1940.0469		

Table 4 shows the analysis of variance for EMG for Data 2 (Second Tracking Task).

Table 4. ANALYSIS OF VARIANCE FOR THE ELECTROMYOGRAPHIC POTENTIAL DEPENDENT VARIABLE - SECOND TASK

Source of variation	DF	SS	MS	F
Anxiety	1	4.9713	4.9713	.8401 N.S.
Task difficulty	3	39.9109	13.3036	2.2483 N.S.
Anx x task dif	3	18.6738	6.2246	1.0519 N.S.
Error	72	426.0356	5.9171	
Noise condition	2	14.9123	7.4562	1.2219 N.S.
Anx x noise cond	2	24.8510	12.4255	2.0363 N.S.
Tsk dif x noise cond	6	69.3777	11.5629	1.8949 N.S.
Anx x tsk dif x noise condition	6	54.8425	9.1404	1.4979 N.S.
Error	144	878.6613	6.1018	
Total	239	1526.3565		

ANALYSIS OF TRACKING ERROR RESPONSES

For both the first (Data 1) and second (Data 2) tracking tasks, task difficulty significantly influenced tracking error performance. Table 5 shows the analysis of variance for the first tracking task.

Figures 4 and 5, show, for both anxiety groups, that tracking error responses approximately double (10% to 20%) when the task was the more difficult rate or velocity tracking.

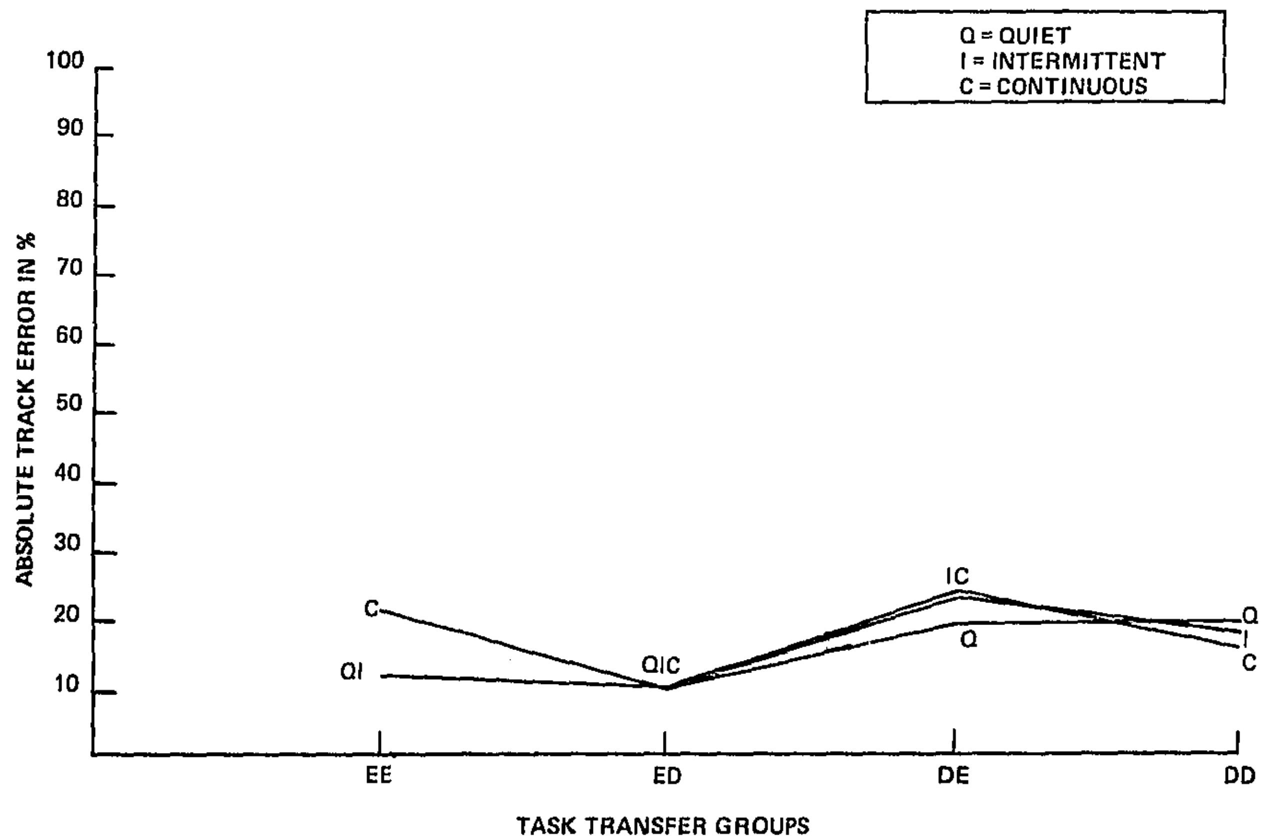


FIGURE 4: LOW ANXIETY TRACK ERROR - DATA 1

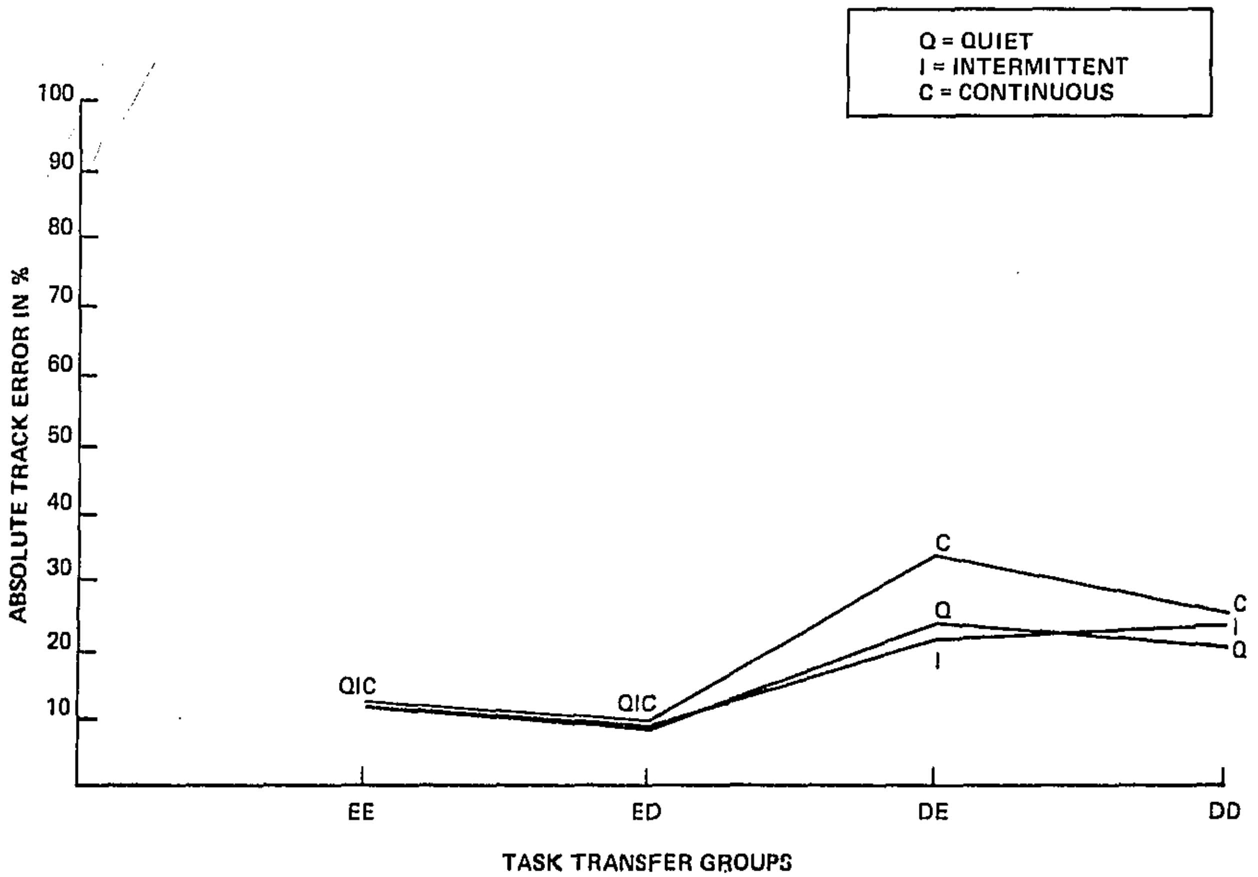


FIGURE 5: HIGH ANXIETY TRACK ERROR - DATA 1

Table 5. ANALYSIS OF VARIANCE FOR TRACK ERROR - FIRST TASK

Source of variation	DF	SS	MS	F
Anxiety	1	3.9106	3.9106	.0817 N.S.
Task difficulty	3	5349.6581	1783.2194	37.2807 p <.01
Anx x task dif	3	295.6206	98.5402	2.0601 N.S.
Error	72	3443.9221	47.8322	
Noise condition	2	94.9963	47.4982	1.3260 N.S.
Anx x noise cond	2	3.3320	1.6660	.0465 N.S.
Tsk dif x noise cond	6	82.4734	13.7456	.3837 N.S.
Anx x tsk dif x noise condition	6	730.5761	121.7627	3.3992 p <.01
Error	144	5158.1347	35.8203	
Total	239	15469.1981		

Table 6 shows the cell means and standard deviations for the first task tracking error.

Table 6. TRACK ERROR CELL MEANS AND STANDARD DEVIATIONS - FIRST TASK

	Q	IN	CN	$\bar{X}$
Hi anxiety				
EE	$\bar{X}$ 12.65 s.d.10.00	$\bar{X}$ 11.76 s.d. 9.40	$\bar{X}$ 12.93 s.d. 9.96	12.45
ED	$\bar{X}$ 6.69 s.d. 4.97	$\bar{X}$ 7.65 s.d. 6.10	$\bar{X}$ 9.47 s.d. 6.02	7.94
DE	$\bar{X}$ 23.04 s.d.15.47	$\bar{X}$ 21.16 s.d.15.08	$\bar{X}$ 33.29 s.d.13.60	25.83
DD	$\bar{X}$ 20.34 s.d.15.56	$\bar{X}$ 24.25 s.d.17.61	$\bar{X}$ 25.08 s.d.17.48	23.19
$\bar{X}$	15.68	16.18	20.19	
Lo anxiety				
EE	$\bar{X}$ 12.01 s.d. 9.38	$\bar{X}$ 12.25 s.d. 9.78	$\bar{X}$ 22.76 s.d.16.35	15.67
ED	$\bar{X}$ 10.25 s.d. 8.04	$\bar{X}$ 10.95 s.d. 9.05	$\bar{X}$ 10.31 s.d. 7.77	10.50
DE	$\bar{X}$ 20.12 s.d.15.01	$\bar{X}$ 24.73 s.d.17.62	$\bar{X}$ 24.64 s.d.16.51	23.16
DD	$\bar{X}$ 18.45 s.d.11.68	$\bar{X}$ 17.65 s.d.11.94	$\bar{X}$ 15.34 s.d.11.34	17.15
$\bar{X}$	15.21	16.40	18.26	

Neuman-Kuhls analysis of row means for both anxiety groups showed that, within each anxiety group, the difficult tracking task resulted in significantly higher error scores than the easy tracking task. Table 7 shows the Neuman-Kuhls analysis for the High Anxiety Group.

Table 7. TRACK ERROR ROW MEANS FOR THE FIRST TASK - HIGH ANXIETY GROUP

	Noise Condition				
Task	Q	IN	CN	$\bar{X}$	
E	12.65	11.76	12.93	12.45	T_2
E	6.69	7.65	9.47	7.94	T_1
D	23.04	21.16	33.29	25.83	T_4
D	20.34	24.15	25.08	23.19	T_3

	T_1	T_2	T_3	T_4
T_1	----	4.51(2.10)*	15.28(2.49)*	17.89(2.73)*
T_2		-----	10.77(2.10)*	13.38(2.49)*
T_3			----	2.61(2.10)*
T_4				----

$q_2 = 2.10$; $q_3 = 2.49$; $q_4 = 2.73$, $p < .05$

Table 8 shows the row means and Neuman-Kuhls analysis for the low anxiety group.

In the high anxiety group, both groups which performed the easy task first had significantly smaller track errors than either of the difficult task groups. Subject differences are apparently operating however, in that the two groups performing the easy task differed significantly. Additionally, the two difficult groups differed significantly from each other. Similar

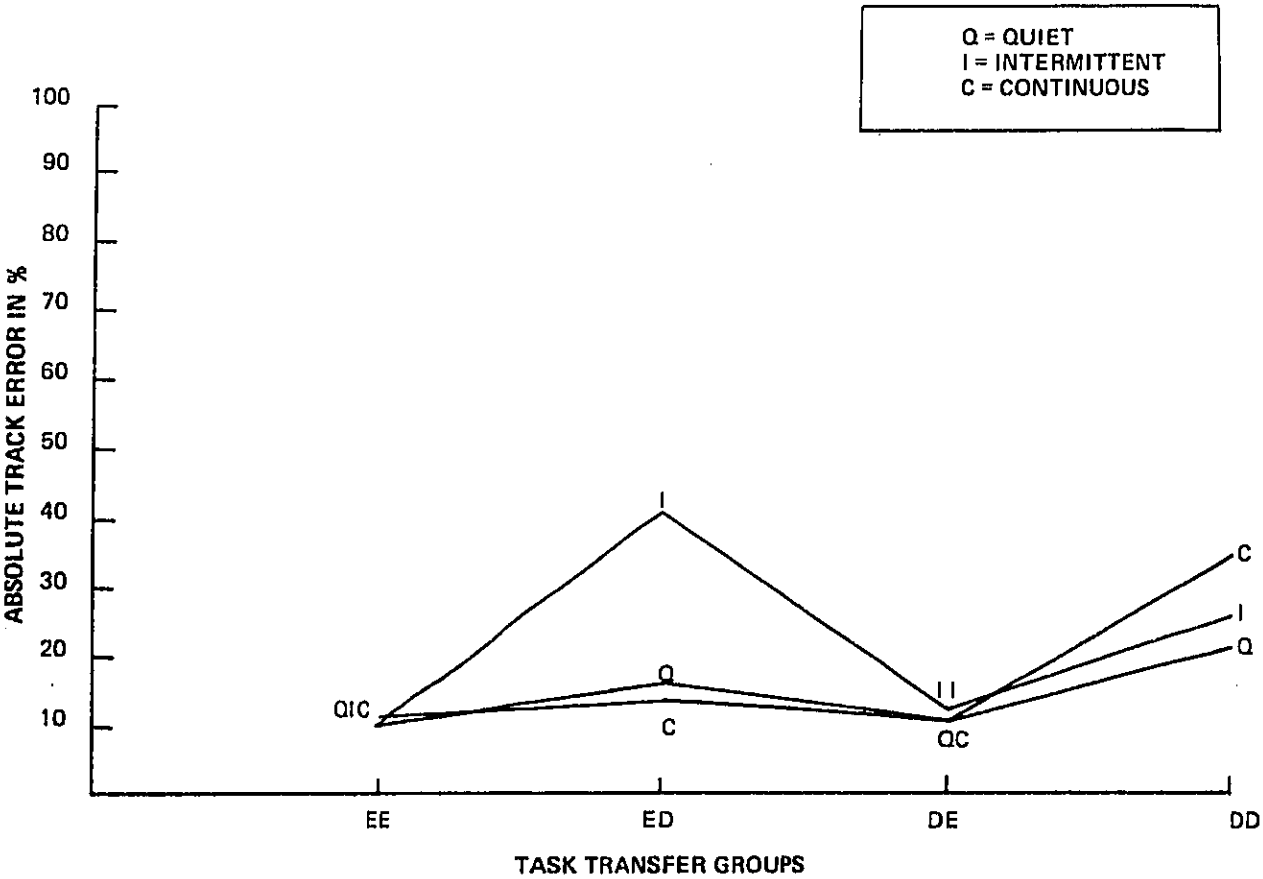


FIGURE 6: HIGH ANXIETY TRACK ERROR - DATA 2

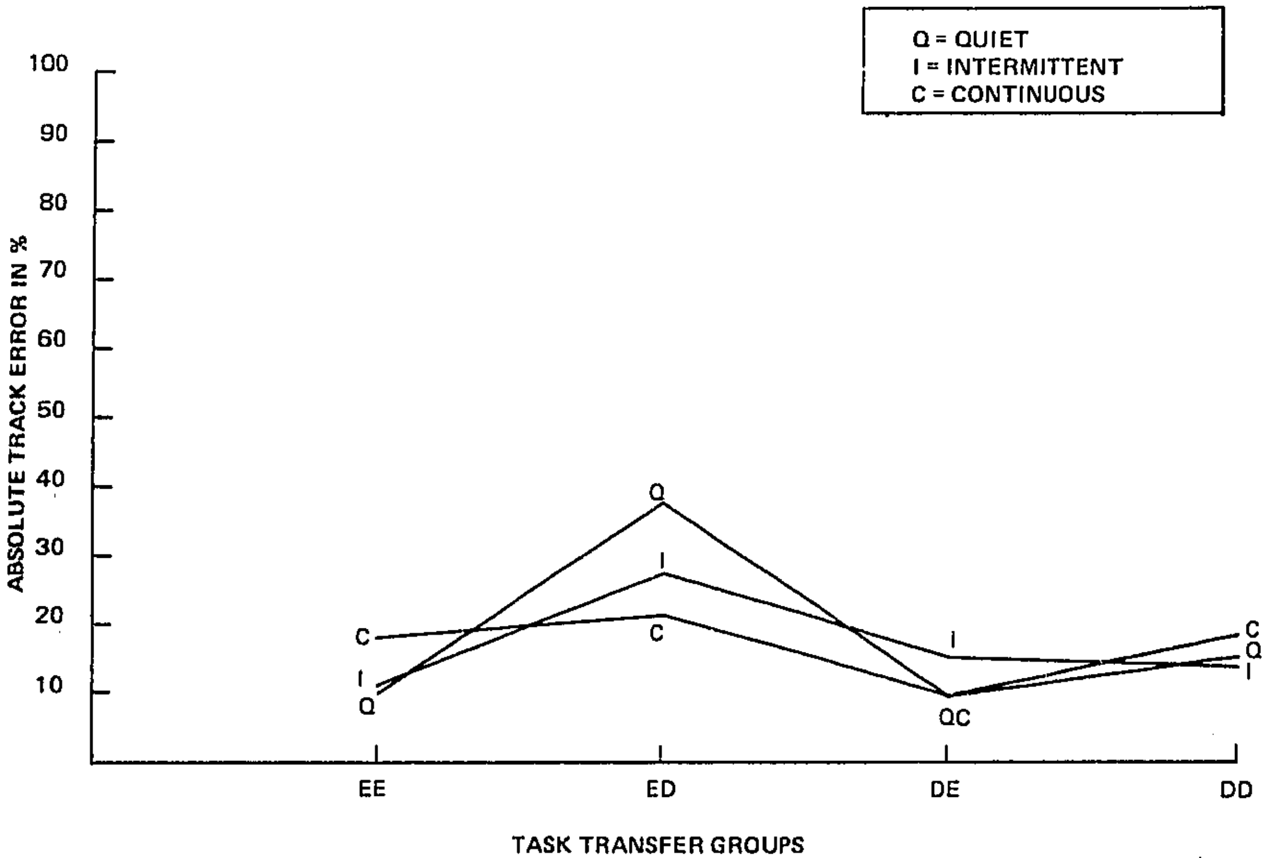


FIGURE 7: LOW ANXIETY TRACK ERROR - DATA 2

results hold for the low anxiety groups, with the exception that one of the easy task groups (T_2) did not have significantly poorer performance than one of the difficult task groups (T_3).

Table 8. TRACK ERROR ROW MEANS FOR THE FIRST TASK- LOW ANXIETY GROUP

	Noise Condition				
Task	Q	IN	CN	$\bar{X}$	
E	12.01	12.25	22.76	15.67	T_2
E	10.25	10.95	10.31	10.50	T_1
D	20.12	24.73	24.64	23.16	T_4
D	18.45	17.65	15.34	17.15	T_3

	T_1	T_2	T_3	T_4
T_1	----	5.17(2.10)*	6.65(2.49)*	12.66(2.73)*
T_2		----	1.48(2.10)	7.49(2.49)*
T_3			----	6.01(2.10)*
T_4				-----

$q_2 = 2.10$; $q_3 = 2.49$; $q_4 = 2.73$, $p < .05$

Table 9 shows the analysis of variance for the second tracking task. (Data 2). These data now include the effects of transfer of training.

Again, significant main effects are present for task difficulty. Additionally, these data now show significant main effects for noise condition.

Figures 6 and 7 show, that for both high and low anxiety groups, the second task (Data 2) tracking error responses increased when the transfer was from an easy to a difficult tracking task.

Table 9. ANALYSIS OF VARIANCE FOR TRACK ERROR - SECOND TASK

Source of Variation	DF	SS	MS	F
Anxiety	1	158.9432	158.9432	1.6266 N.S.
Task difficulty	3	7806.7954	2602.2651	26.6321 p <.01
Anx x task dif	3	261.7668	87.2556	.8929 N.S.
Error	72	7035.2170	97.7113	
Noise cond	2	244.7820	122.3910	5.5308 p <.01
Anx x noise cond	2	56.8519	28.4259	1.2845 N.S.
Task dif x noise cond	6	507.0714	84.5129	3.8191 p <.01
Anx x task dif x noise condition	6	194.5361	32.4227	1.4651 N.S.
Error	144	3186.5429	22.1287	
Total	239	19222.5994		

The Data 2, analysis of variance indicated significant main effects for noise condition on tracking error, as well as for task difficulty.

Table 10 shows the cell means and standard deviations for the second task (Data 2) tracking error responses.

Neuman-Kuhls analysis of row means for both anxiety groups showed that within each anxiety group, the difficult tracking task resulted in significantly higher error scores than the easy tracking task. Table 11 shows the row means and Neuman Kuhls analysis for the high anxiety group.

Table 12 shows the row means and Neuman-Kuhls analysis for the low anxiety group (Data 2).

In the high anxiety group (second task), the difficult task (T_4) preceded by a difficult task resulted in significantly higher track error scores than either the difficult task (T_3) preceded by an easy task or an easy task (T_1) preceded by an easy task. This finding also applied for the difficult task (T_2) followed by an easy task. Regardless of prior (first) task, as long as the second task was difficult, error scores were significantly higher than when the second task was easy. For the low anxiety group, the difficult task (T_4) preceded by an easy task resulted in significantly higher track error scores than either the difficult task (T_3) preceded by a difficult task or the easy task (T_2) preceded by an easy task or the easy task following a difficult task (T_1).

Table 10. TRACK ERROR CELL MEANS AND STANDARD DEVIATIONS - SECOND TASK

	Q	IN	CN	$\bar{X}$
Hi anxiety				
EE	$\bar{X}$ 9.99 s.d. 8.68	$\bar{X}$ 9.78 s.d. 8.56	$\bar{X}$ 11.06 s.d. 9.39	10.28
ED	$\bar{X}$ 15.43 s.d.12.07	$\bar{X}$ 40.29 s.d. 8.92	$\bar{X}$ 13.27 s.d.10.24	23.00
DE	$\bar{X}$ 11.43 s.d. 9.36	$\bar{X}$ 12.96 s.d. 9.45	$\bar{X}$ 12.44 s.d. 8.06	12.28
DD	$\bar{X}$ 22.12 s.d.16.52	$\bar{X}$ 27.54 s.d.17.18	$\bar{X}$ 35.97 s.d.14.48	28.54
$\bar{X}$	14.74	22.64	18.19	
Lo anxiety				
EE	$\bar{X}$ 9.99 s.d. 8.57	$\bar{X}$ 11.11 s.d. 9.24	$\bar{X}$ 20.25 s.d.14.06	13.78
ED	$\bar{X}$ 37.79 s.d.12.42	$\bar{X}$ 27.74 s.d.17.82	$\bar{X}$ 21.75 s.d.15.71	29.09
DE	$\bar{X}$ 11.59 s.d. 9.83	$\bar{X}$ 16.86 s.d.12.29	$\bar{X}$ 11.20 s.d. 9.16	13.22
DD	$\bar{X}$ 15.59 s.d.11.54	$\bar{X}$ 14.49 s.d.11.12	$\bar{X}$ 18.78 s.d.11.89	16.29
$\bar{X}$	18.74	17.55	18.00	

Table 11. TRACK ERROR ROW MEANS FOR THE SECOND TASK - HIGH ANXIETY GROUP-TASK EFFECT

	Noise condition				
Task	Q	IN	CN	$\bar{X}$	
E	9.99	9.78	11.06	10.28	T_1
D	15.43	40.29	13.27	23.00	T_3
E	11.43	12.96	12.44	12.28	T_2
D	22.16	27.54	35.97	28.54	T_4

	T_1	T_2	T_3	T_4
T_1	-----	2.0(5.11)	12.72(6.05)*	18.26(6.62)*
T_2		-----	10.72(5.11)*	16.26(6.05)*
T_3			-----	5.54(5.11)*
T_4				-----

$q_2 = 5.11$; $q_3 = 6.05$; $q_4 = 6.62$ $\underline{p} < .05$

Table 12. TRACK ERROR ROW MEANS FOR THE SECOND TASK - LOW ANXIETY GROUP-TASK EFFECT

	Noise Condition				
Task	Q	IN	CN	$\bar{X}$	
E	9.99	11.11	20.25	13.78	T_2
D	37.79	27.74	21.75	29.09	T_4
E	11.59	16.86	11.20	13.22	T_1
D	15.59	14.49	18.78	16.29	T_3

	T_1	T_2	T_3	T_4
T_1	-----	.56(5.11)	3.07(6.05)	15.87(6.12)*
T_2		-----	2.51(5.11)	15.31(6.05)*
T_3			-----	12.80(5.11)*
T_4				-----

$q_2 = 5.11$; $q_3 = 6.05$; $q_4 = 6.62$ $\underline{p} < .05$

Tables 13 and 14 show the noise group cell and column means for each anxiety group, along with the Neuman-Kuhls analysis.

Table 13. TRACK ERROR COLUMN MEANS FOR SECOND TASK - HIGH ANXIETY GROUP - NOISE EFFECT

	Noise condition		
Task	Q	IN	CN
E	9.99	9.78	11.06
D	15.43	40.29	13.27
E	11.43	12.96	12.44
D	22.16	27.54	35.97
$\bar{X}$	14.74	22.64	18.19
	T_1	T_3	T_2
	T_1	T_2	T_3
T_1	-----	3.45(2.10)*	7.90(2.53)*
T_2		-----	4.45(2.10)*
T_3			------

$q_2 = 2.10$; $q_3 = 2.53$, $p < .05$

Neuman-Kuhls analysis of column means revealed that only the high anxiety group (second task) displayed significant decrements in tracking accuracy as a result of noise condition. In the high anxiety group, the IN condition produced the greatest decrement, followed by the CN condition. In the low anxiety group, the Q condition produced the largest mean decrement in tracking error, however, this result was clearly not significant.

Table 14. TRACK ERROR COLUMN MEANS FOR SECOND TRACKING TASK - LOW ANXIETY GROUP - NOISE EFFECT

	Noise condition		
Task	Q	IN	CN
E	9.99	11.11	20.25
D	37.79	27.74	21.75
E	11.59	16.86	11.20
D	15.59	14.49	18.78
$\overline{X}$	18.74	17.55	18.00
	T_3	T_1	T_2

	T_1	T_2	T_3
T_1	----	.45(2.10)	1.19(2.53)
T_2	----	----	.74(2.10)
T_3			----

$q_2 = 2.10$; $q_3 = 2.529$, $\underline{p} < .05$

Figures 8 and 9 show, for the easy and difficult task respectively, the significant main effect of task difficulty and the significant interaction effect of anxiety, task difficulty and noise condition on tracking error for the first task (Data 1). Figures 10 and 11 (which include transfer of training effects) show, for the easy and difficult task respectively, the significant main effects of task difficulty and noise condition, as well as the significant task difficulty by noise condition interaction effect on tracking error for the second task (Data 2). By inspection, the significant main effect of noise condition occurred during the difficult tracking task (Figure 11).

ANALYSIS OF STROOP RESPONSES

Table 15 displays the analysis of variance for the Stroop color-word responses. There was a significant main effect for noise condition.

Table 16 shows the cell and column means for the Stroop color-word responses. These data are collapsed over anxiety groups.

In the Neuman-Kuhls analysis, these data were collapsed across anxiety groups with the resulting column means:

Q = 1.24 secs.
IN = 1.33 secs.
CN = .87 secs.

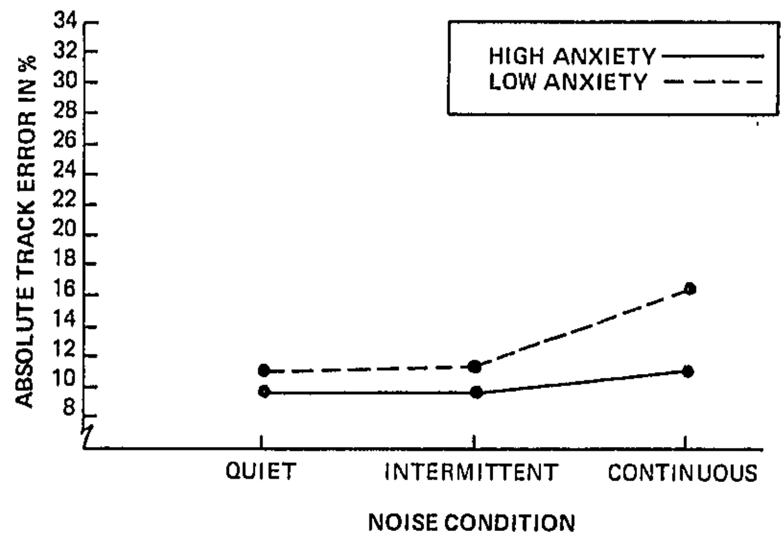


FIGURE 8: EASY TRACKING TASK - DATA 1

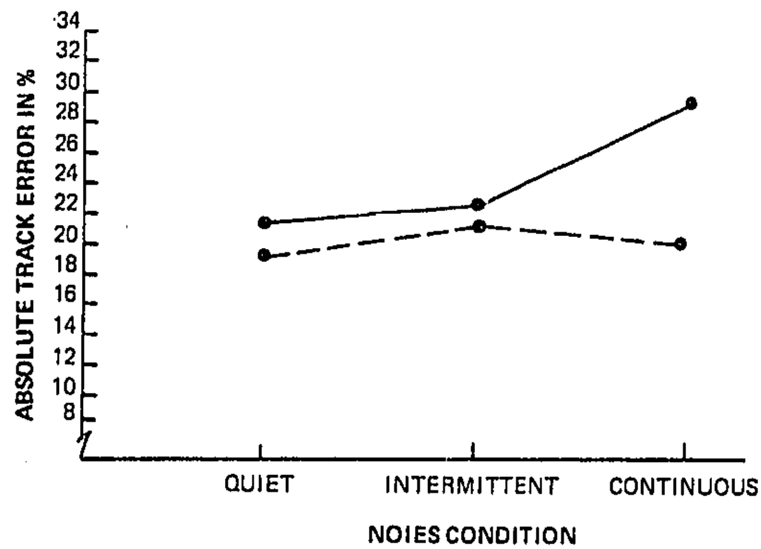


FIGURE 9: DIFFICULT TRACKING TASK - DATA 1

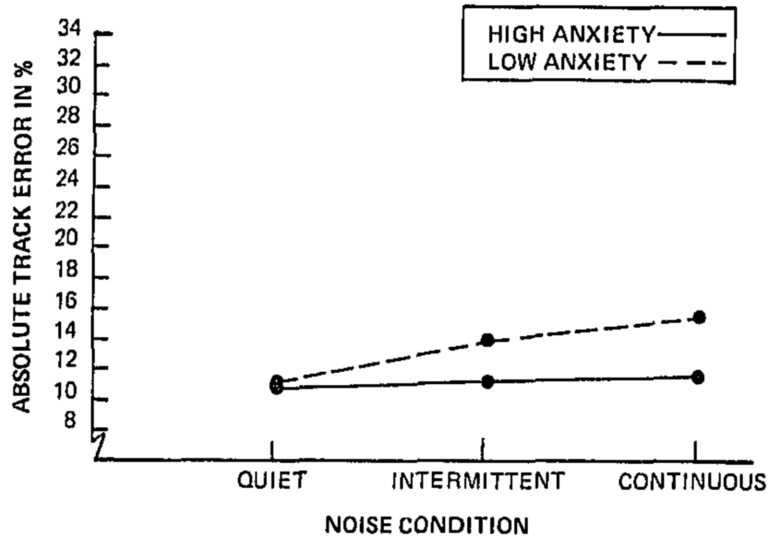


FIGURE 10. EASY TRACKING TASK - DATA 2

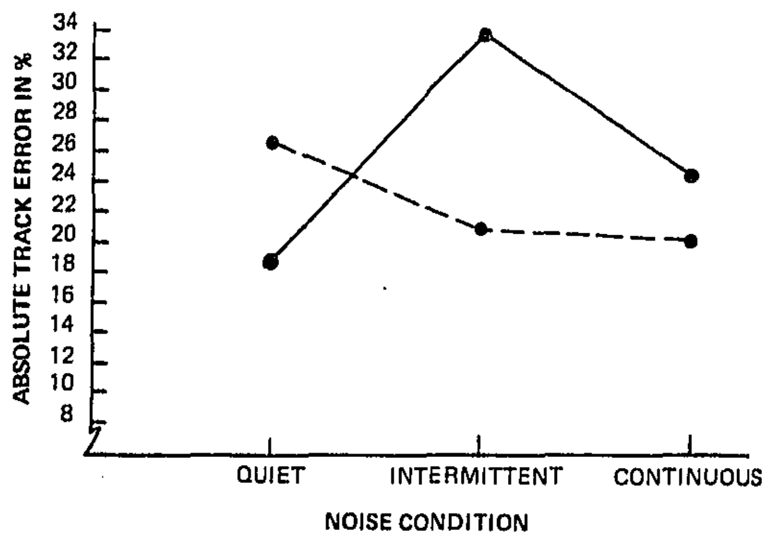


FIGURE 11. DIFFICULT TRACKING TASK - DATA 2

Table 15. ANALYSIS OF VARIANCE FOR STROOP COLOR WORD RESPONSES

Source of variation	DF	SS	MS	F
Anxiety	1	11.2509	11.2509	2.8339 (N.S.)
Task difficulty	3	3.7769	1.2590	.3171 (N.S.)
Anx X tsk dif	3	6.2205	2.0735	.5209 (N.S.)
Error	72	285.8412	3.9700	
Noise cond	2	30.5040	15.2520	3.5196*
Anx X noise cond	2	6.2864	3.1432	.7253 (N.S.)
Tsk dif x noise cond	6	51.6820	8.6137	1.9877
Anx x tsk dif x noise condition	6	43.3612	7.2269	1.6677 (N.S.)
Error	144	624.0214	4.3334	
Total	239	1054.7181		

$p < .05$

In every cell, subjects read the color-words faster, after being exposed to the experimental condition. These ranged from a low of .11 seconds faster to a maximum of 2.79 seconds faster.

ANALYSIS OF HEART RATE RESPONSES

Heart rates changed significantly as a function of task difficulty and noise condition (Data 1- First Task) and Task Difficulty alone (Data 2- Second task). Tables 17 and 18 show the analyses of variance for both first and second tasks (Data 1 and Data 2) respectively.

Table 16. STROOP COLOR-WORD RESPONSE TIMES BY CELL MEAN

	High Anxiety			Low anxiety			
Task seq	Q	IN	CN	Q	IN	CN	$\bar{X}$
EE	1.37	1.71	.24	1.15	1.10	.11	.94
ED	1.38	2.62	.67	.80	.28	1.02	1.12
DE	.70	.95	2.22	.71	1.24	1.15	.83
DD	2.79	1.68	.96	1.07	1.10	.64	1.37
$\bar{X}$	1.56	1.74	1.02	.93	.93	.73	

	T_1-Q	T_2-IN	T_3-CN
T_1	---	.37	.46
T_2		---	.09
T_3			---

$q_2 = .64$ $q_3 \approx .76$ $p < .05$ (N.S.)

Table 17. ANALYSIS OF VARIANCE FOR HEART RATE RESPONSES-DATA 1-FIRST TASK

Source of variation	DF	SS	MS	F
Anxiety	1	11.2873	11.2873	.1032 (N.S.)
Task difficulty	3	1004.5748	334.8583	3.0628*
Anx x tsk dif	3	73.0760	24.3587	.2228 (N.S.)
Error	72	7871.6596	109.3286	
Noise cond	2	223.3829	111.6915	3.0559*
Anx x noise cond	2	123.3906	61.6953	1.6880 (N.S.)
Tsk dif x noise cond	6	154.6267	25.7711	.7051 (N.S.)
Anx x tsk dif x noise condition	6	156.1343	26.0224	.7119 (N.S.)
Error	144	5263.0169	36.5487	
Total	239	14813.7616		

*p <.05

TABLE 18. ANALYSIS OF VARIANCE FOR HEART RATE RESPONSES-DATA 2-SECOND TASK

Source of variation	DF	SS	MS	F
Anxiety	1	91.1439	91.1439	.7495 (N.S.)
Task difficulty	3	1141.0576	380.3525	3.1280*
Anx x tsk dif	3	261.6626	87.2209	.7173
Error	72	8754.8715	121.5924	
Noise cond	2	187.8425	93.9212	2.6679 (N.S.)
Anx x noise cond	2	81.9342	40.9671	1.1637 (N.S.)
Tsk dif x noise cond	6	169.4013	28.2335	.8019 (N.S.)
Anx x tsk dif x noise cond	6	108.1718	18.0286	.5121 (N.S.)
Error	144	5069.4002	35.2041	
Total	239	15875.5860		

*p <.05

Table 19 shows the cell, column and row means for the Data 1 (First Task) heart rate responses. Since there was no main or interaction effects for the anxiety measure, these data are collapsed across the anxiety variable.

Neuman-Kuhls' analysis of column means showed that although the F test was significant, the differences between noise condition, heart rate means was not large enough to produce a significant multiple comparison. Row mean analysis indicated that mean heart rate for one of the Difficult Task groups (T_1) was significantly lower (57.54 BPM) than any of the other task groups. This again apparently reflects the operation of uncontrolled individual differences. There is no a priori reason to expect T_1 versus T_3 differences since both groups performed the same task.

TABLE 19. HEART RATE MEAN RESPONSE - FIRST TASK

	Noise condition				
Task	Q	IN	CN	$\overline{X}$	
E	59.53	63.17	71.38	64.69	(T_2)
E	75.14	62.17	63.10	66.80	(T_4)
D	63.52	67.25	68.58	66.45	(T_3)
D	56.24	60.11	56.29	57.54	(T_1)
$\overline{X}$	63.60(T_2)	63.17(T_1)	64.83(T_3)		

	T_1	T_2	T_3	
T_1	----	.13	1.66	NEUMAN-KUHLS
T_2		---	1.53	COLUMN MEANS
T_3			---	

$q_2 = 1.87$; $q_3 = 2.25$; $p < .05$ (N.S.)

	T_1	T_2	T_3	T_4	
T_1	---	7.15*	8.91*	9.26*	NEUMAN-KUHLS
T_2		----	1.76	2.11	ROW MEANS
T_3			----	.35	
T_4				----	

$q_2 = 2.80$; $q_3 = 3.17$; $q_4 = 3.39$, $p < .05$

Table 20 shows the heart rate means for the second tracking task. Since there were no main or interaction effects for either anxiety or noise condition, these data are collapsed across both variables.

TABLE 20. HEART RATE MEAN RESPONSE - SECOND TASK

	E	D	E	D
$\overline{X}$	63.84	70.01	68.41	59.14
	T_2	T_4	T_3	T_1

	T_1	T_2	T_3	T_4
T_1	---	4.70	9.27*	10.87*
T_2		----	4.57	6.17
T_3			---	1.6
T_4				----

$q_2 = 7.00$; $q_3 = 8.42$; $q_4 = 9.26$; $p < .05$

The T_1 group mean heart rate was significantly lower than either the T_3 or T_4 group. These data indicate significantly lowered heart rates for a difficult task group preceeded by a difficult task or an easy task. Again, regardless of prior task, as long as the second task was difficult, heart rates tended to be lower.

REGRESSION ANALYSES

Since track error, heart rate, and Stroop chart reading times reflected the effects of either task difficulty or noise conditions, it was deemed appropriate to assess the contribution of these independent variables to the dependent variables in terms of the proportion of variance accounted for.

ANALYSIS STRATEGY

Multiple stepwise regression analysis was used to evaluate the contribution of the independent variables to the dependent variables. The major independent variables were: Anxiety Level, Noise Condition, and Tracking Task Difficulty. These variables were manipulated either by selection and assignment of subjects (Anxiety level) or directly as a function of the experimental conditions (Noise Condition and Tracking Task Difficulty). Two additional variables, Eye Dominance and Time of Day, known to be correlated with motor skills and tracking task performance were controlled statistically by adding them to a second regression analyses along with the three major independent variables. The restricted model includes only the major independent variables. The full model includes the former plus those variables whose effects are to be controlled statistically. An analysis of regression comparison of the two models yields the same results as the traditional analysis of covariance (Roscoe, 1975). The coefficients of determination for each model are compared using an _F_ test. If the _F_ is significant, the covariates contribute a significant proportion of variance to the dependent variable. Using this technique six regression analyses were performed for Data 1 (First Tracking Task); a full and a restricted model for each of the three dependent variables.

TRACK ERROR DATA 1 (RESTRICTED MODEL)

Table 21 reflects the summary data for the restricted model regression analysis. The three major independent variables account for a significant (F = 18.4727, df = 3,236, p <.01) but relatively small (R^2 = .19) proportion of the Tracking Error variance. Since Data 1 represents the first of each subjects two tracking tasks, the contribution of task difficulty alone to tracking error (R^2 = .19) represents the difference between the easy and the difficult tracking task.

Table 21. ANALYSIS OF VARIANCE FOR THE RESTRICTED REGRESSION MODEL FOR TRACKING ERROR - (DATA 1)

		SV	DF	SS	MS	F
R	.43598	Regression	3	5290.70	1763.56	18.4627*
R^2	.19008	Residuals	236	22543.62	95.52	
S.E.	12.02125	Total	239	27834.32		

*p <.01

Table 22. REGRESSION SUMMARY TABLE FOR THE RESTRICTED MODEL FOR TRACKING ERROR - (DATA 1)

Variable	R	R^2	R^2 Change	r	b
Task difficulty	.40506	.16407	.16407	.40506	4.06
Noise condition	.43585	.18997	.02589	.16754	2.61
Anxiety	.43598	.19008	.00011	.06731	.06
Constant					.37

TRACK ERROR-DATA 1 (FULL MODEL)

Table 23 shows the regression analysis of variance for tracking error for the full regression model which includes time of day and eye dominance.

Table 23. ANALYSIS OF VARIANCE FOR THE FULL REGRESSION MODEL FOR TRACKING ERROR - (DATA 1)

		SV	DF	SS	MS	F
R	.45537	Regression	4	5771.86	1442.96	15.3703*
R^2	.20736	Residuals	235	22062.46	93.88	
S.E.	11.93057	Total	239	27834.32		

p <.01

Table 24 shows the summary data for the full model.

Table 24. REGRESSION SUMMARY TABLE FOR THE FULL MODEL FOR TRACKING ERROR - (DATA 1)

Variable[a]	R	R^2	R^2 Change	r	b
Task difficulty	.40506	.16407	.16407	.40506	4.52090
Noise condition	.43585	.18997	.02589	.16754	2.59801
Time	.45213	.20442	.01445	-.12766	-.83190
Eye dominance	.45537	.20736	.00295	-.10133	-.99007
Constant					5.45925

[a]The contribution of anxiety to residual reduction was less than the "F to enter" the equation, therefore anxiety does not appear.

As described, the restricted and full regression models were compared using an *F* test. The full model was not significantly different from the restricted model. (F = .8537 df = 2,238) indicating that neither eye dominance nor time of day contributes significantly to the reduction of residual variance.

EMG - DATA 1 - RESTRICTED AND FULL MODELS

The independent variables in either the restricted or full model did not contribute significantly to electromyographic changes. The restricted model multiple R was .14960 which was not significant (F = 1.8024, df = 3,236, p <.05). In the full model, the multiple R was .16824 which was not significant (F = 1.7112, df= 4,235, p <.05)

HEART RATE- DATA 1 - RESTRICTED AND FULL MODELS

Although task difficulty and noise condition produced significant changes in heart rate means as evidenced by the analysis of variance, the independent variables in both the full and restricted models were not significantly related to heart rate changes. For the restricted model, the multiple R with heart rate was .08489 (F = .8602, df = 2,237. p < .05). In the full model, the multiple R was .14953 (F = 1.799, df = 3,236, p <.05.)

STROOP RESPONSES - RESTRICTED MODEL

The independent variables in the restricted model did not account for a significant proportion of the variance in reading time. Table 25 shows the regression analysis of variance.

Table 25. ANALYSIS OF VARIANCE FOR THE RESTRICTED REGRESSION MODEL FOR STROOP RESPONSE TIME

	SV	DF	SS	MS	F
R = .13171	Regression	3	45.67	15.2243	2.517(N.S.)
R^2 =.02301	Residuals	211	1276.24	6.048	
S.E. = 2.43239	Total	214	1321.91		

The multiple R (.13171) was not significant (F = 2.68, df = 3,211, p <.05)

DATA 2 - REGRESSION ANALYSIS

The second tracking task of each experimental session comprised the Data 2 information. Independent variables in the restricted model were not significantly related to tracking error nor did inclusion of eye dominance or time of day improve the relationship (F = .6762, df = 2,237 p > .05, F = 1.1117, df = 5,234 p > .05, respectively). Multiple analysis of variance of these same data however, reflected significant main effects for task sequence on tracking error and noise condition on tracking error. It is quite evident from these data that a significant difference in tracking error was present for the groups differing in task difficulty of the second tasks. The student of analysis of variance vis-a-vis regression analysis will recognize the apparent conflict between regression analysis and analysis of variance across tracking tasks. For Data 1, subjects were relatively consistent in the tracking error performance across noise conditions as evidenced by the significant multiple R and group means were different across task difficulty. For Data 2, although, groups differed on their mean tracking performance as a function of task difficulty as evidenced by the significant main effects for task sequence, there was obvious inconsistency in individual performance across noise conditions as indicated by the absence of a significant multiple R.

EMG - DATA 2 - RESTRICTED AND FULL MODELS

Variables in the restricted model were significantly related to EMG changes (F = 4.5935, df = 3,236, p < .01). Table 26 shows the analysis of variance for regression and Table 27 displays the summary data.

Table 26. ANALYSIS OF VARIANCE FOR THE RESTRICTED REGRESSION MODEL FOR EMG- (DATA 2)

		SV	DF	SS	MS	F
R	.23816	Regression	3	64.09	21.36	4.5935
R^2	.05672	Residual	236	1065.89	4.51	
S.E.	2.66571					

*p <.01

Table 27. REGRESSION SUMMARY TABLE FOR THE RESTRICTED REGRESSION MODEL FOR EMG - (DATA 2)

Variable	R	R^2	R^2 change	r	b
Task difficulty	.19092	.03645	.03645	.19092	.46393
Noise condition	.23513	.05529	.01884	-.13385	-.45992
Anxiety	.23816	.05672	.00143	.03646	-.05028
Constant					37.72333

The variables involved in the full model were significantly related to EMG (F = 3.0905, df = 5,234, p <.01).

Table 28. ANALYSIS OF VARIANCE FOR THE FULL REGRESSION MODEL FOR EMG-DATA 2

	SV	DF	SS	MS	F
R = .24102	Regression	5	65.642	13.1284	3.0905*
R^2 = .05809	Residuals	234	1064.348	4.548	
S.E.= 2.68170	Total				

*p <.01

Table 29. REGRESSION SUMMARY TABLE FOR THE FULL REGRESSION MODEL FOR EMG DATA 2

Variable	Multiple R	R Square	Simple R	Beta
Task difficulty	.19092	.03645	.13385	.19779
Noise	.23513	.05529	.13385	.13387
Anxiety	.23816	.05672	.03646	.04014
Eye dominance	.24080	.05798	.02583	.03562
Time	.24102	.05809	.00258	.01040

The multiple R (.24102) was significant (F = 3.09, df = 5,234, $p < .01$ and the variables now account for 5.8% of criterion variance composed of 5.67% in the restricted model. Comparison of the two models indicates that addition of time of day and eye dominance does not account for a significantly increased proportion of criterion variance. (F = 1.7618, df = 2,234; p >.05)

HEART RATE - DATA 2 - RESTRICTED AND FULL MODELS.

The variables in both the restricted and full models were not significantly related to the heart rate criterion. For the restricted model, R = .07332; F = .4251, df = 3,236, p >.05 (N.S.). For the full model, R = .19283; F = 2.26, df = 5,234, p >.05 (N.S.).

SECTION VI

DISCUSSION

Data analysis indicate the complexity of the relationships between physiological and motor skills variables when noise is used in combination with other variables. There were no significant mean differences between groups in electromyographic potential changes as a function of either noise profile, anxiety condition or task difficulty. Tracking error responses reflected significant changes as a function of some but not all the variables. For example, in both tracking tasks, errors increased when the task was the more difficult rate plus velocity tracking. This is not an altogether unexpected result. This increase in error was evident, independent of the anxiety and noise conditions. Within the anxiety groups however, there were some anomalous results. In the high anxiety subjects, the two groups which performed the easy task first, differed significantly but not greatly from each other, as did the two groups performing the difficult task first. This is clearly an indication of subject differences operating. Similar significant, but slight differences exist in the 40 low anxiety subjects. For the first tracking task, there were no main effects for either noise condition or anxiety level of subjects.

Tracking error data from the second task, which includes transfer of training effects, again shows significant main effects of task difficulty and also noise condition (high anxiety only). Again, track errors increased for the difficult task. In the high anxiety group, regardless of prior (first) task, as long as the second task was difficult, error scores were significantly higher than when the second task was easy.

For the second task, both intermittent (IN) and continuous (CN) noise profiles resulted in significant decrements in track error performance compared to a quiet (Q) condition. In high anxiety subjects, IN produced the greatest decrement; however, within the low anxiety group, the IN profile did not produce differential effects compared to CN or Q. High anxiety subjects are apparently more susceptible to the effects of differing noise profiles than are low anxiety subjects.

The poorest tracking performance occurred when high anxiety subjects were required to switch from the easy to the difficult task during exposure to intermittent noise. The best tracking performance was demonstrated by high anxiety subjects also, who performed the less difficult task under the quiet (no noise) condition. These results are similar to those found by Goodstein, Speilburger, Williams, and Dahlstrom, 1955 (Speilburger, 1966) where performance of the high anxiety subjects was inferior to that of the low anxiety subjects for the more difficult tasks and superior on the less difficult tasks. The results, according to the authors, would be predicted from Drive Theory. An extension of Drive Theory might be called the "response interference hypothesis", which states that task-irrelevant responses, which in some situations may interfere with efficient performance, are more easily elicited in high than in low anxiety subjects (Spence, 1956; Taylor, 1956; Taylor, 1959). According to Child (1954), "high anxiety subjects tend to react emotionally to many experimental situations, even those in which stress stimulation is not explicity employed" (Speilburger, 1966).

Previous investigations concerning stress effects on complex task performance between anxiety groups have "demonstrated all varieties of relationships, suggesting that these stress conditions are complex in their effects and interact with a number of variables to determine performance" (Farber, 1955; Lazarus, Deese, & Osler, 1952; Speilburger, 1966). One relatively consistent finding has been that with certain complex speed tasks, "the performance of high anxiety subjects will decline earlier on the stress continuum than low anxiety subjects, and at any given point, be more pronounced". I. G. Sarason and Palola (1960) found that with simpler speed tasks, the high anxiety subjects improved their performance under stress (Speilburger, 1966). This finding is consistent with the results of the present experiment in which high anxiety subjects performed the more simple tracking task with lower average error scores than the low anxiety subjects regardless of noise condition. Additionally, I. G. Sarason and Palola (1960) suggest that "task difficulty was the variable determining the direction of the effect of stress on performance and hence the nature of the interaction between stress and anxiety level" (Speilburger, 1966). This relationship was also evident in the present experiment since there was a significant interaction between stress, (noise condition) anxiety and task difficulty. By visual inspection, the significant anxiety, stress (noise condition), and task difficulty interaction only occurred during the more difficult tracking task.

STROOP RESPONSES

The average performance of subjects in each cell improved as a result of the experimental conditions. Stroop Chart reading times were lower after the experimental session regardless of the independent variable combination. Intermittent noise produced the largest significant reduction in reading time. However, the quiet condition produced a significantly larger reduction than did the continuous conditions. It is not clear that the noise profile alone, or its mode of presentation are directly responsible for the reduction. It is conceivable that merely being in a controlled environment, or attending to a demanding tracking task produced the reading time reductions. It is therefore inappropriate, as a result of these data, to infer noise facilitated performance. The arousal value of attending to a demanding task, independent of noise stimulation, is indicated by the data in Table 16. When both the first and second tasks were the more difficult rate or velocity tracking, the largest facilitation of Stroop Chart reading occurred (2.79 - cell; 1.37 - group average).

HEART RATE RESPONSES

Heart rates changed by less than one full beat per minute as a function of the differing noise environments. This result has no particular practical significance. Across task difficulty groups there was a significant decrease in heart rate as a function of performing the more difficult rate plus velocity tracking in one group performing this task. This result is seen as spurious in that a similar group of subjects performing the same task did not show a like decrease (Table 19).

Results of previous studies of heart rate changes following the presentation of a noxious stimulus (loud tone) show similarly conflicting findings. Epstein (Speilburger, 1972) concludes that "the findings on heart rate are, to say the least, surprising." Epstein found marked accelerative and decelerative reactions in different individuals which cancel each other out. "It is apparent that heart rate is a complexly controlled system, and that strong stimulation does not always produce acceleration." Similar results are also reported by Eason et. al. (1964). Interestingly, a possible explanation for the lack of significant heart rate changes as a function of differing noise environments, particularly the intermittent noise condition may coincide with Epstein's conclusion that "it is only after the stimulus is familiar within the experimental context, such as after it has been presented a number of times in the count-up, that its presentation by surprise is as apt to produce decelerative as accelerative reactions." Epstein further states that a "possible explanation of the differential response to a familiar and unfamiliar strong stimulus presented by surprise is that in the former case some degree of habituation has already taken place, and the stimulus, therefore, is less threatening, and less apt to evoke orienting reflexes, with corresponding heart-rate deceleration. An unfamiliar strong stimulus, on the other hand, is apt to evoke defensive reflexes, with corresponding heart-rate acceleration."

Finally, in considering the inconsistencies of human physiological response to stress, Cattel & Nesselroade (Speilburger, 1972) state that there is an overlap of anxiety and stress in the physiological area, and in the awareness of pressure and tension and "it is evident that a person can be stressing himself most when he is calm, concentrated, and successfully working hard."

Because subjects were run at different times on experimental days and because of the different visual orientation of the subjects to the display depending on experimental booth, these two factors were statistically controlled by adding them to a regression equation with the major independent variables. In effect, these former factors were considered as covariates. Coefficients of determination for each regression model were compared by an F Test. Addition of the time of day and eye dominance variables did not significantly reduce residual variance for any of the dependent measures for either the first or second task. Further, when considering only the major independent variables (anxiety, noise condition and task difficulty), significant but relatively small proportions of variance were accounted for. For example, in Data 1, the major independent variables accounted for only 19% of the variance in track error, 2% of the variance in Stroop response time, 19% of the variance in EMG changes and 6% of the variance in heart rate. In practical terms therefore, the independent variables, though they may have resulted in significant mean differences, do not contribute much to our understanding of the differences. Instead, the data suggest that no simple empirical or theoretical statement about the influence of noxious stimulation (noise) can be made and that in predicting its effect on performance, account must be taken of such variables as the nature of the task materials, the nature and direction of task transfer effects, the manner in which the noxious stimulation or its anticipation is introduced into the situation, the instructions subjects are given about its significance, the trait anxiety level of the subjects, and the number and intensity of the noxious stimulation. Previously, such variables had not been systematically investigated and the interactions that exist among them have been little understood, if at all.

ANXIETY AS A MODERATOR OF NOISE EFFECTS ON HUMAN PSYCHOMOTOR PERFORMANCE

Previous findings by Elbiet and DiScipio (1971), that extroverts were found to display greater decrements in psychomotor performance while experiencing noise stimulation than introverts, were not fully supported by the results of this study. Instead, it appears that the psychomotor performance of those assigned to the high anxiety group was effected to a greater extent by the noise environment than was the performance of the low anxiety subjects. The relationship between A-STAIT, A-TRAIT anxiety and introversion is described in the MMPI Handbook (Dahlstrom et. al, 1973) High "0" scale males (introverts), display many of the personality traits of high anxiety subjects with marked insecurities and worries. Anxiety, as measured by the IPAT STAI-A scale, simiarly involves feelings of tension, nervousness, worry and apprehension with high scores reflecting states of intense apprehension and fearfulness approaching panic and low scores reflecting feelings of calmness and serenity.

The finding that level of anxiety is a variable that differentially effects psychomotor performance (track error) is both interesting and significant in terms of the possible consequences regarding the effects of moderate noise on human behavior. Watson (1930) postulated only two innate fear stimuli: loss of support and loud noises. It would seem inappropriate to classify 84dBA as a loud noise. The question that then arises is, what is it about moderate noise as a stimulus that interacts with and degrades the psychomotor performance of subjects who demonstrate an elevated (but not pathological) level of anxiety? That is, what possible mechanisms are operating that would allow us to understand the relationship between anxiety, noise, and psychomotor performance. We believe that fright (as an explanation) is a class of fear-related emotions which are relatively stimulus bound, moreover, fright reactions may differ among themselves depending on their objects (Speilburger, 1972). It does not appear likely that there is, in this experiment, the necessary appropriate stimuli to warrant the development of the emotion of fear. Substantial efforts were made to reduce fear related stimuli (i.e., pleasant background music was played prior to the start of the experiment, instructions were low keyed, relaxed and designed to reduce the impact of upper body disrobing and EKG electrode application, and fellow students normally assisted during the experiment.

Lazarus & Averill (Speilburger, 1972) state that "there can be little doubt that theorizing with respect to anxiety is still in the elementary stages, somewhat like the concept of air in 18th century chemistry." However, there is a significant body of literature on the subject of the causes and consequences of anxiety (Speilburger, 1972) which classifies anxiety into three general categories in terms of etiology. They are (1) Primary Overstimulation (2) Response Unavailability and (3) Cognitive Incongruity.

According to the neobehavioristic learning theorists, pain is the unconditioned stimulus for fear and anxiety. Organisms have an upper limit to stimulation. Overstimulation is associated with feelings of being overwhelmed and bombarded with stimuli, corresponding to the statement, "Stop it, I can't stand it anymore." Epstein (Speilburger, 1972) states that "organisms are energy systems that are responsive to energy inputs and must maintain their levels of excitation, no less than their other internal states, within homeostatic limits in order to survive. Small increments in arousal cause the individual to attend to his environment and to register the stimulus associated with the increment. Large increments in arousal cause a reduction in receptivity to and registration of stimulation and are experienced as unpleasant. It appears that arousal is controlled through inhibition, which is intimately associated with the establishment of expectances. Through the process of inhibition, stimuli such as moderately loud noises that were initially attended to only because of their energetic properties become registered or 'learned', and thereafter can be responded to in terms of their cue properties." It may be that for low anxiety subjects, the introduction of moderate noise as an environmental stimulus serves as a general facilitator of performance because it causes the organism to attend to its environment and raises its general activation level. Evidence for this can be seen in the consistent decrease in the time needed to successfully respond to the post-experimental STROOP color-word chart. In every cell, subjects read the color-words faster after being exposed to the experimental condition. This finding is contrary to other studies involving high sound pressure levels (Sommer & Harris, 1972) and indicates the arousing effect of the experimental condition alone. Several studies (Scott, 1966; Malmo, 1957) show that performance increases as a function of activation level up to a point and then declines as general arousal is further increased. This concept would be in agreement with Di Scipio's (1971) finding that white noise facilitates psychomotor response for an optimal period of time, after which decrements were observed. However, with subjects displaying higher than normal anxiety with concomitant internal feelings of tension, nervousness, worry and apprehension, further increases in external sources of stimulation, such as moderate noise, may well be debilitating to some degree due to the requirement that the organism cope with heightened levels of general arousal, particularly since "increases in arousal are produced by any stimulation, internal or external" (Epstein, 1967).

According to Lazarus (1966), anxiety is viewed as a state in which the individual experiences diffuse arousal but is unable to direct that arousal into purposive action. Moreover, "it is the arousal and the defenses against it, and not the anxiety, and the defenses against it, that are responsible for the primary symptoms of the behavior disorders. In this respect, it has been established that experimental neurosis can be evoked by conditions that are arousing, but not frightening, such as difficult discriminations and the disconfirmation of established expectancies."

The notion that anxiety is more noxious to an organism than fear appears to have adaptive value. Epstein notes that "one of the most common distinctions made between anxiety and fear is that in fear the source of the threat is known and in anxiety it is unknown." Epstein further states that fear is an avoidance motive. If there were no restraints, internal or external, fear would support the action of flight. As mentioned previously, anxiety can be defined as unresolved fear, or alternately, as a state of undirected arousal following the perception of threat. Given a crisis, it is important that the organism rapidly assess the situation and take immediate action. In the course of evolution, man, as an animal, has also developed the ability to, when danger is perceived, generate a heightened state of arousal that provides nonspecific preparation for flight or fight. "Thus, it is adaptive for the state of diffuse arousal to be an acutely unpleasant one, and for it to become more so in time, thereby providing the animal (man) with a powerful incentive to resolve indecision and to select a course of action."

Thus, it would appear that noise need not be so loud as to generate fear to be arousing or anxiety provoking. Diffuse arousal, resulting from moderately noxious stimulation (noise) coupled with heightened states of trait anxiety should, according to Epstein, be perceived by the organism as acutely unpleasant, thereby providing the input to select a course of action. However, in the case of environmental noise, particularily intermittent, uncontrollable noise, there may be no appropriate course of action available to the organism, resulting in unresolved and undirected arousal, anxiety and frustration.

Epstein (Speilburger, 1972) concludes by noting that the relationship between frustration and anxiety is evident. "Frustration has been accorded special significance in psychological theorizing because of its relevance for maladaptive behavior and the normal stresses of everyday living. The consequences of heightened states of diffuse arousal have been observed to include restlessness and tension, aggression, apathy, withdrawal, disorganized behavior, regression and escape." All of which appear to be common symptoms of the "urban din" we must live in.

An additional mechanism by which environmental noise may interact with the second basic source of anxiety can be described as Response Unavailability. In this experiment, as in real life, the subject could not control the noise. It was just there. Mandler (1961) states that "in a state of arousal, the organism who has no behavior available to him, who continues to seek situationally or cognitively appropriate behavior is 'helpless' and also may consider himself, in terms of the common language, as being in a state of anxiety." Mandler further states that "any such arousal - peripheral or central, environmentally or behaviorally induced - will lead to a feeling of helplessness when no cognitive or behavioral sequence appropriate to the situation is available, or when no substitute sequence or escape from the field provides a means of terminating the state of arousal."

This raises the question of what would happen if escape from a source of threat (noxious stimulation) were blocked. Studies by Seligman and his colleagues (Speilburger, 1972) indicate that "a state of helplessness produced by unavoidable noxious stimulation is extremely debilitating and tends to be self-maintaining." This factor may also apply in this experiment, particularly for those subjects who displayed higher than normal states of anxiety and who were locked in a sealed acoustic chamber and subjected to unpleasant stimulation over which they had no control.

A third basic parameter that affects arousal level is Cognitive Incongruity which is determined by the consistency of one's expectations and the ability to establish an adequate cognitive model of events (Epstein, 1967). In the present experiment, subjects were not able to predict the onset or duration of the intermittent noise. (Event Certainty, Temporal Uncertainty). There is considerable evidence in the research literature indicating that in a normal subject population the violation of expectancies beyond a certain point induces anxiety. "It would appear that an accurate expectation with regard to the occurrence of noxious stimulation is generally sought" (Epstein, 1967; Speilburger, 1972). In the case of intermittent noise, the violation of expectancies is clearly evident, since the experimental results indicate that high anxiety subjects were more affected by the intermittent noise condition than by the continuous noise condition, whereas the low anxiety subjects were not significantly affected by noise conditions at all. Again, demonstrating the need to specify anxiety level when predicting the effects of moderate noise on human behavior.

Interestingly, the concept of Cognitive Incongruity may also be a factor in the apparently anomalous finding that low anxiety subjects (2nd task) displayed the greatest decrement in track error performance when transferring from the easy to difficult task under the quiet (no noise) condition. Under both anxiety conditions, the transfer from the easy to the difficult task resulted in the greatest track error performance decrement. This finding appears consistent with the concept of Cognitive Incongruity in that expectations concerning the difficulty of the tracking task were most severely violated under this condition. A possible explanation for the low anxiety subject's poor performance under these conditions (quiet) may be linked to overall activation levels, i.e., insufficient internal and external stimulation to perform well under these conditions. This would be consistent with Scott's (1966) findings concerning activation level and performance previously mentioned. Several other studies have also suggested an inverted U-shaped function as describing the relationship between motivation and performance (Malmo, 1957, 1958, & 1959) generally by appealing to the notion that "difficult" tasks elicit more emotionality than "easy" ones, particularly in high anxiety subjects. Such studies have generally confirmed the notion that "subjects who were low in both anxiety score and experimentally manipulated stress and those who were high in both were poorer in performance than members of the other two groups" (Speilburger, 1966).

Normally, anticipation is of great importance for research on anxiety (and stress in general), due to the emerging cognitive appraisal by the person of the significance of the event. Breznitz (Speilburger, 1972) speaks of the "incubation of threat", observing in his research and that the longer subjects had to wait, the greater the stress, as measured by heart rate, just prior to shock. Breznitz found that most of the stress reaction (as measured autonomically) took place during the anticipatory period, with little further increment during the noxious stimulus period itself. Furthermore, a dissertation by Folkins (1970) showed that degree of stress varied significantly as a function of anticipation as time increases from 5-30 seconds, with a further rise up to 1 minute, with a drop in disturbance from 3-5 minutes - though it rose slightly at 20 minutes. In the present experiment, baseline autonomic data was taken during the 2nd minute period, followed by 2 minutes of instructions, with the onset of the noise following during the 4 to 9 minute period, thereby elevating the baseline response and depressing the experimental condition response. It appears, according to Folkins, that with 3-5 minutes to appraise the situation; "subjects are better able to develop self-assuring coping responses, and therefore display less stress." These findings may well have contributed to the lack of practical significance between baseline and experimental condition physiological arousal levels in the present experiment.

Finally, interruption of cognitive processes appears to generate a state of heightened arousal (Mandler, 1961). Dr. Gordon Davis, University of California Medical School at Davis, provides a "clinical" description of interruption (due to noise) in its purest form (Speilburger, 1972). The case study of a 9 year old boy is described - when noise or activity going on at home reaches a certain point - an explosion of behavior results - "he may go out and ride his bicycle to get away from it," apparently as the result of a deficient ability to carry out a cognitive plan when experiencing interruption or environmental disorganization. It may be that one of the primary effects of moderate environmental noise is its interrupting, disorganizing quality, which would be particularly debilitating to those subjects who already experience substantial internal arousal as the result of elevated trait anxiety levels.

In sum, "human beings are motivated to structure their world and to find ways of dealing with it largely because of the characteristics of their anxiety system. At low levels of anxiety, the process is a constructive one, leading to expanded awareness and increasing control of nature. At high levels, it produces defensive retrenchment, including delusional interpretations of events (any explanation is better than none), and compulsive rituals for dealing with them (any action is better than none)" (Epstein, 1967; Speilburger, 1972). Thus, for organisms that already possess heightened internal states of arousal (high trait anxiety), by adding stimulation from the environment (noise) that violates or precludes the development of expectancies, (intermittent noise) it can then be expected that decrements in psychomotor performance should result, and as part of the "cost" to the organism, frustration can also be expected to occur with all of the negative ramifications that now appear to plague our highly industrialized, urban society.

SECTION VII

REFERENCES

1. Anderson, P. A., "Social Class, Noise and Performance," Dissertation Abstracts International, 33, No. 6-B, pp 2784 (1973).

2. Bull, A. J., "Effects of Noise and Intolerance of Ambiguity Upon Attraction for Similar and Dissimilar Others," Journal of Social Psychology, 88, No. 1, pp 151-152 (1973).

3. Campbell, B. A., "Interaction of Aversive Stimuli: Summation or Inhibition?," Journal of Experimental Psychology, 78, No. 2, pp 181-190 (1968).

4. Child, I. L., "Personality," Annual Review of Psychology, No. 5, pp 149-170 (1954).

5. Dahlstrom, W. G., Welsh, G. S., and Dahlstrom, L. E., "On MMPI Handbook, Volume I," University of Minnesota Press (1973).

6. Deese, J., Lazarus, R. S., and Keenan, J., "Anxiety, Anxiety Reduction and Stress in Learning," Journal of Experimental Psychology, 46, pp 55-60 (1953).

7. DiScipio, W. J. "Psychomotor Performance as a Function of White Noise and Personality Variables," Perceptual and Motor Skills, 33, No. 1, pp 82 (1971).

8. Dyer, F. N., "The Stroop Phenomenon and It's Use in the Study of Perceptual, Cognitive, and Response Processes," Memory and Cognition, 1, No. 2, pp 106-120 (1973).

9. Eason, R. G., Harter, M. R., and Storm, W. F., "Activation and Behavior. I: Relationship Between Physiological 'Indicants' of Activation and Performance During Investigation of Nonsense Syllables Using Differing Induced Tension Conditions," Perceptual, Motor Skills, No. 19. pp 95-110 (1964).

10. Edsell, R. D., "The Effect of Noise on Some Interrelationships Between Social Interaction and Anxiety," (Doctoral dissertation, Drexel University) Ann Arbor, Mich: University Microfilms, No. 734040 (1973).

11. Elliott, C. D., "Noise Tolerance and Extraversion in Children," British Journal of Psychology, 62, No. 3, pp 375-380 (1971).

12. English, H. B., and English, A. V., "A Comprehensive Dictionary of Psychological Terms, David McKay Co., New York (1958).

13. Epstein, S., "Toward a Unified Theory of Anxiety," In B. A. Mather (Ed.), Progress in Experimental Personality Research, Academic Press, New York, Vol 4, pp 1-89 (1967).

14. Epstein, S., "The Nature of Anxiety with Emphasis Upon It's Relationship to Expectancy," In C. D. Spielburger (Ed.), Anxiety, Current Trends in Theory and Research Vol II, Academic Press, New York, pp 291-337 (1972).

15. Farber, I. E., "The Role of Motivation In Verbal Learning and Performance," Psychological Bulletin, No. 52, pp 311-327 (1955).

16. Fechter, J. V., "The Effects of Noise on Human Learning," (Doctoral dissertation, University of South Dakota) Ann Arobr, Mich: University Microfilms, No. 72-32728 (1972).

17. Folkins, C. H., "Temporal Factors and the Cognitive Mediators of Stress Reactions," Journal of Personality and Social Psychology, No. 14, pp 173-184 (1970).

18. Glass, D. C., and Singer, J. E., "Experimental Studies of Uncontrollable and Predictable Noise," Representative Research in Social Psychology, 4, No. 1, pp 165-183 (1973).

19. Goodstein, L. D., Spielburger, C. D., Williams, J. E., and Dahlstrom, W. G., "The Effects of Serial Position and Design Difficulty on Recall of the Bender-Gestalt Test Designs," Journal of Consultive Psychology, No. 19, pp 230-234 (1959).

20. Grether, W. F., "Two Experiments on the Effects of Combined Heat, Noise, and Vibration Stress," Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, No. AMRL-TR-71-113 (1972).

21. Gulian, E., "The Factor 'Difficulty of the Task' and It's Influence Upon Performance Level Under Noise Conditions," Revista de Psihologie, 18, No. 3, pp 323-330 (1972).

22. Gulian, E., "Psychological Consequences of Exposure to Noise, Facts and Explanations," Proceedings of the International Congress on Noise as a Health Problem, U. S. Environmental Protection Agency, Washington, D. C., No. 550/9-73-008.

23. Harcum, E. R. and Monti, P. M., "Cognitions and Placebos in Behavioral Research in Ambient Noise," Perception & Motor Skills, 37, No. 1, pp 75-79 (1973).

24. Harris, C. S., and Schoenberger, R. W., "Combined Effects of Noise and Vibration on Psychomotor Performance," USAF AMRL Technical Report, No. 70-14, pp 24 (1970).

25. Jansen, G., and Hoffman, H., "Noise-Induced Changes in Fine Motoricity and Noise Induced Feelings of Annoyance Which Depend Upon Definite Personality Dimensions," Army Foreign Science and Technology Center, Charlottesville, VA., No. FSTC-HT-23-236-71 (1971).

26. Jauhiainen, T., Kohonen, A., and Jauhiainen, M., "Combined Effect of Noise and Neomycin in the Cochlea," Acta Oto-Laryngologica, 73, No. 5, pp 387-390 (1972).

27. Kryter, K. D., "The Effects of Noise on Man," Academic Press, New York (1970).

28. Kumar, P., and Mathur, C. N., "Sex and Noise Destractibility," Indian Journal of Applied Psychology, No. 6, pp 13-14 (1969).

29. Lazarus, R. S., Psychological Stress and the Coping Response, Vol 3, McGraw-Hill, New York, pp 96-102 (1966).

30. Lazarus, R. S., and Averill, J. R., "Emotion and Cognition: With Special Reference to Anxiety," In C. D. Spielburger (Ed.), Anxiety, Current Trends in Theory and Research, Vol II, Academic Press, New York, pp 242-283 (1972).

31. Lazarus, R. S., Deese, J., and Osler, S. F., "The Effects of Psychological Stress Upon Performance," Psychological Bulletin, No. 49, pp 293-317 (1952).

32. Malhur, C. N., "Age as a Factor in Noise Distractibility," Manas, 19, No. 1, pp 31-33 (1972).

33. Malmo, R. B., "Anxiety and Behavioral Arousal," Psychological Review, No. 64, pp 276-287 (1957).

34. Malmo, R. B., "Measurement of Drive: An Unsolved Problem in Psychology," In M. R. Jones (Ed.), Nebraska Symposium on Motivation, Lincoln, Nebraska, University of Nebraska Press, pp 229-265 (1958).

35. Malmo, R. B., "Activation: A Neuropsychological Dimension," Psychological Review, No. 66, pp 367-386 (1959).

36. Mandler, G., "Helplessness: Theory and Research In Anxiety," In C. D. Spielburger (Ed.), Anxiety, Current Trends in Theory and Research, Vol II, Academic Press, New York, pp 360-378 (1972).

37. Mason, R. K., "The Influence of Noise on Emotional States," Journal of Psychomatic Research, 13, No. 3, pp 275-282 (1969).

38. Myers, J. L., Fundamentals of Experimental Design. Allyn and Bacon, Boston (1966).

39. Renshaw, F. M., "The Combined Effects of Heat and Noise in Work Performance," Dissertation Abstracts International, 33, No. 8-B, pp 3699 (1973).

40. Roscoe, J. T., Fundamental Research Statistics for the Behavioral Sciences, Holt, Rinehart and Winston, Inc. (1969).

41. Sarason, I. G., and Palola, E. G., "The Relationship of Test and General Anxiety, Difficulty of Task, and Experimental Instructions to Performance," Journal of Experimental Psychology, No. 59, pp 185-191 (1960).

42. Scott, W. E., JR., "Activation Theory and Task Design," Organizational Behavior and Human Performance, No. 1, pp 3-30 (1966).

43. Spielburger, C. D., Anxiety and Behavior, Academic Press, New York (1966).

44. Spielburger, C. D., Anxiety, Current Trends In Theory and Research, Vol II, Academic Press, New York (1972).

45. Spence, J. T., and Spence, K. W., "The Motivational Components of Manifest Anxiety: Drive and Drive Stimuli," In C. D. Spielburger (Ed.), Anxiety and Behavior, Academic Press, New York (1966).

46. Spence, K. W., Behavior Theory and Conditioning, Yale University Press, New Haven, Conn. (1956).

47. Stephans, S. D., "Personality and the Slope of Loudness Function," Quarterly Journal of Experimental Psychology, 22, No. 1, pp 9-13 (1970).

48. Taylor, J. A., "Drive Theory and Manifest Anxiety," Psychological Bulletin, No. 53, pp 303-320 (1956).

49. Taylor, J. A., "Manifest Anxiety, Response Interference and Repression," Experimental Foundations of Clinical Psychology Symposium, University of Virginia Medical School, April (1959).

50. Watson, J. B., Behaviorism (2nd ed.), Norton & Company, New York (1930).

SECTION VIII

GLOSSARY

Activation Level - The preparation or the tendency toward action. The level of activation of a whole system is the degree of tension.

Anxiety - A feeling of threat, especially of a fearsome threat, without the person's being able to say what he thinks threatens.

Anxiety, Free - A chronic state of anxiety which attaches to almost any situation or activity of the individual.

Anxiety, Trait - A chronic state of anxiety which remains unattached and constant over all situations and activity of the individual.

A-STATE - State anxiety may be conceptualized as a transitory emotional state or condition that varies in intensity and fluctuates over time.

A-TRAIT - Trait Anxiety refers to relatively stable individual differences in anxiety proveness.

Eye Dominance - A tendency to fixate objects with one eye rather than with both and to depend primarily upon the impressions of that one eye, though the non-preferred eye is not blind.

Extravert - A person who tends strongly to the attitude of extraversion. Extraversion has three aspects to include outward oriented interests, ease of social adjustment and open behavior.

Homeostasis - The maintenance of consistency of relationships or equilibrium in the bodily processes, whether physical or psychological. Any departure from the equilibrium sets in motion activities that tend to restore it.

Inhibition - A mental state in which the range and amount of behavior is curtailed, beginning or continuing a course of action is difficult, and there is a peculiar hesitancy as if restrained.

Introvert - A person who tends strongly to the attitude of introversion. Introversion has three aspects to include inward oriented interests, difficulty of social adjustment and secretive behavior.

IPAT - Institute for Personality Assessment and Testing.

Neurosis - A mental disorder ill-defined in character but milder than psychosis. Neurosis are usually characterized as disfunction within the individual, as opposed to between the individual and his environment.

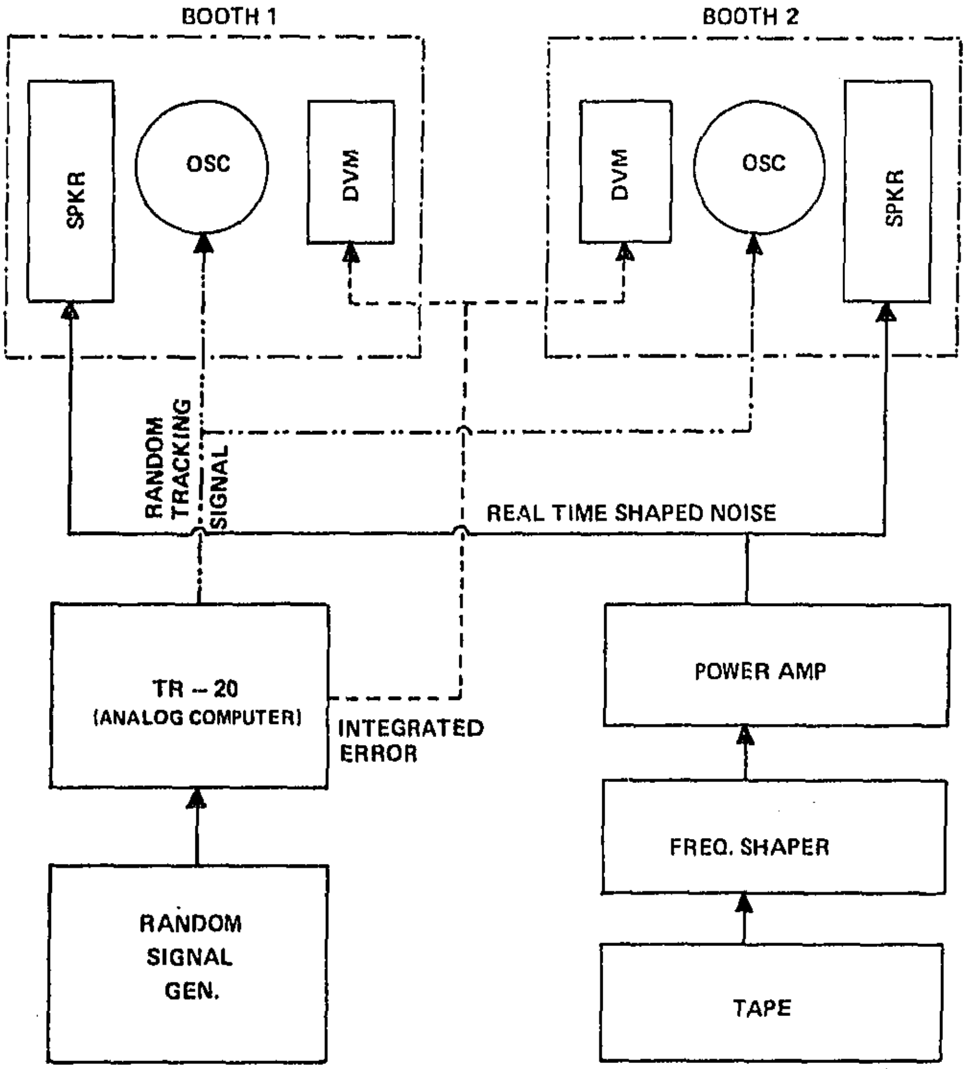
STAI-A - State-Trait Anxiety Inventory - Scale A - consists of twenty statements that ask people to describe how they generally feel.

Stroop Chart - A collection of stimulus words describing colors which are printed in a visual color other than the word. This maximizes the interference between the written and reproduction colors.

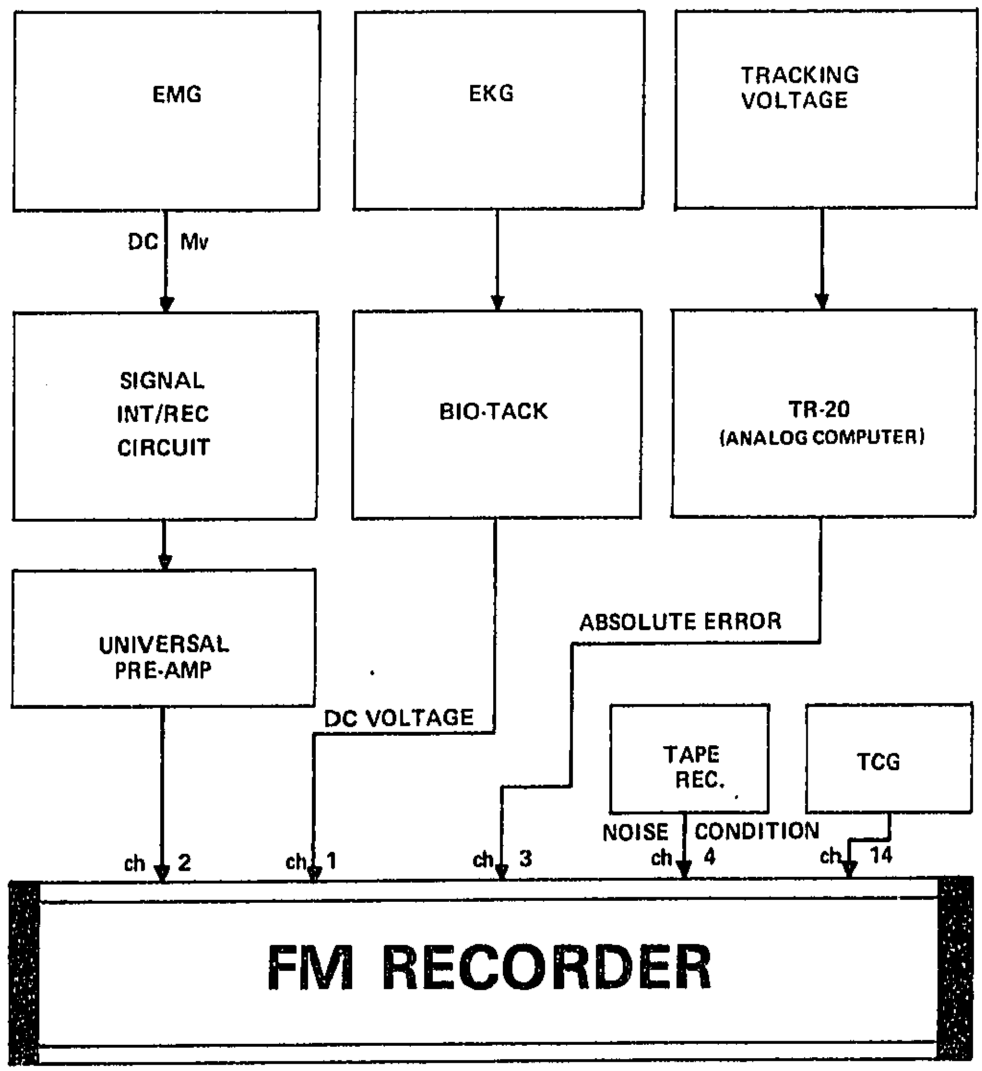
SECTION IX

APPENDICES

INPUTS


BOOTH 1
BOOTH 2
SPKR
OSC
DVM
DVM
OSC
SPKR
RANDOM TRACKING SIGNAL
REAL TIME SHAPED NOISE
TR – 20
(ANALOG COMPUTER)
INTEGRATED ERROR
POWER AMP
FREQ. SHAPER
RANDOM SIGNAL GEN.
TAPE

OUTPUTS



EMG
EKG
TRACKING VOLTAGE
DC
Mv
SIGNAL INT/REC CIRCUIT
BIO-TACK
TR-20 (ANALOG COMPUTER)
UNIVERSAL PRE-AMP
ABSOLUTE ERROR
DC VOLTAGE
TAPE REC.
TCG
NOISE
CONDITION
ch 2
ch 1
ch 3
ch 4
ch 14
FM RECORDER

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/1-77-038	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE BEHAVIORAL AND PHYSIOLOGICAL CORRELATES OF VARYING NOISE ENVIRONMENTS		5. REPORT DATE June 1977 issuing date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Lawrence F. Sharp, John F. Swiney, Mickey R. Dansby, Stephen C. Hyatt, Dale E. Schimmel		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Behavioral Sciences and Leadership United States Air Force Academy, Colorado 80840		10. PROGRAM ELEMENT NO. 1GA085
		11. CONTRACT/GRANT NO. EPA-IAG-D4-0537
12. SPONSORING AGENCY NAME AND ADDRESS Office of Health and Ecological Effects - Wash., DC Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE EPA/600/18

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Eighty male college juniors and seniors were dichotomized into either High or Low Anxiety groups. Each subject experienced a househole noise profile under a quiet (50 dBA), intermittent (84 dBA) and continuous (84 dBA) noise condition, while performing either an easy or difficult pursuit tracking task. Heart rate, electromyographic potentials, and tracking error responses were evaluated. Results indicated significant (P .01) main efforts for task difficulty and noise condition and significant (P .01) interaction effects for task difficulty, noise condition and anxiety level (as measured by the IPAT Self Analysis Form) of subjects. The significant noise effect occurred for the difficult task condition during the second tracking period (which includes transfer of training effects) indicating that factors such as task difficulty, direction of task transfer effects, duration of noise exposure as well as anxiety level of subjects appear to be important variables affecting human psychomotor performance in noise environments below 85 dBA. These findings appear to be consistent with previous research which suggests that task difficulty is the variable determining the direction of stress (noise) effects on psychomotor performance and the nature of the interaction between stress and anxiety level. The present findings are therefore seen as supporting the concepts of the response interference hypothesis and the inverted-U function between stress and performance.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Noise Anxiety Heart Rate Behavior Physiological Effects	Electromyographic Potential Psychomotor Performance	06S 06P

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 80
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

* U.S. GOVERNMENT PRINTING OFFICE : 1977 0-241-037/59

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Technical Information Staff
Cincinnati, Ohio 45268

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300
AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. ENVIRONMENTAL PROTECTION AGENCY
EPA-335

Special Fourth-Class Rate
Book

If your address is incorrect, please change on the above label; tear off; and return to the above address.
If you do not desire to continue receiving this technical report series, CHECK HERE ☐; *tear off label, and return it to the above address.*