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ABSTRACT

In order to determine ways in which disabled and non-disabled people react to low levels of stress, the reliability of heart and respiratory measures under different conditions was studied. Eighty-five subjects (paraplegics, cardiacs, and physically normal controls) were given a variety of tests with the following results: over a 1-week interval the physiological measures were less reliable than most psychometric paper and pencil measures; respiration was more reliable than cardiac measures; and the more dynamic the stimulus situation, the lower the reliability of the physiological measure. No consistent patterns of a relationship between physiological measures and the relatively more static paper and pencil tests was found. Indications were that under low levels of stress the patients in different disability categories seemed to show differential responses in the disability affected areas. (Author/RJ)

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SIGNIFICANT FINDINGS FOR REHABILITATION WORKERS

This study concerned itself with measures of heart and respiratory function. Specifically it attempted to view these important physiological measures in a psychometric model. That is, the questions were raised are the measures reliable, does the reliability vary under different stimulus conditions, are patterns of responses obtained from persons with cardiac and respiratory disabilities different from one another and from the physically normal, and finally, are the responses related to personality or demographic factors?

The major findings of the study suggested that over a one week interval these physiological measures are not as reliable as most psychometric measures. In fact, in many cases, the reliability coefficients yielded correlations not significantly different from zero. In general, respiration was found to be more reliable than cardiac measures. In general, too, it was found that the more dynamic the testing situation the lower the reliability of the physiological measure. These findings influenced the answers to the other questions in that the phenomena which are fundamentally not reliable are unlikely to show significant relationships with other phenomena. Nonetheless, where adequate reliability coefficients were obtained, it was found that under low levels of stress, cardiac patients showed significant departures in heart rate from physically normal and paraplegic patients. Paraplegic patients on the other hand showed significantly different respiratory responses to low levels of stress when compared with cardiac or physically normal subjects. No consistent patterns of a relationship between physiological measures and the relatively more static paper and pencil tests was found.

Investigators are cautioned against studying the relationship between physiological and other measures unless they have substantial data with regard to reliability values of the phenomena under investigation. Failure to find significant relationships between physiological and other measures may be a function of low reliability. Nonetheless, the present study indicated that under conditions of low levels of stress the patients in different disability categories seemed to show differential responses in the disability affected areas.

Rehabilitation Series 4

MEASUREMENT OF CARDIAC AND RESPIRATORY RESPONSES IN PHYSICALLY DISABLED AND NON-DISABLED GROUPS IN A VARIETY OF PSYCHOLOGICAL AND INDUSTRIAL CONDITIONS

Project No. RD-2141-M

HUMAN RESOURCES CENTER

ALBERTSON, NEW YORK 11507

1970

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INA MEND INSTITUTE

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HUMAN RESOURCES CENTER

The INA MEND Institute was established in May of 1968 through an agreement between the Insurance Company of North America and Human Resources Center to bring the newest in rehabilitation research to the insurance industry and to all of mankind. The Institute with its Executive Director and President of Human Resources Center, Henry Viscardi, Jr. is located at Human Resources Center, Albertson, New York. The Center is composed of three components: Human Resources School which offers a fully accredited education to previously homebound youngsters from pre-school through high school; Human Resources Research and Training Institute which conducts research, training, and demonstration programs in solving the problems of the handicapped; and the internationally known non-profit demonstration training and work center, Abilities Inc. The INA MEND Institute conducts seminars and serves as a research laboratory for the established MEND rehabilitation program of the Insurance Company of North America. The MEND program offers, on a national basis, to recently injured people a medical, financial, and vocational rehabilitation program. To supplement this program the INA MEND Institute offers practical research in rehabilitation and safety. Also through the INA MEND Institute Research Library, recent publications are distributed to INA Nurses and other professionals in the field of rehabilitation.

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James W. Ferriman (Ex Officio)
Senior Vice President
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FOREWORD

Physicians, psychologists and laymen alike all have a clear impression of what happens to a person's breathing and heart rates when he is exposed to conditions of severe emotional stress We know that they increase markedly under such conditions and typically try to avoid such stress in most of our activities. Until the present time, what has not been studied is the cardiac and respiratory response to conditions of low level stress. These low levels of stress are far more characteristic of daily functioning both on and off the job.

The particular concern of an intensive research project conducted at Human Resources Center was the question of how individuals, both disabled and non-disabled, react differently to low levels of stress. The answer to this question might help not only in matching employee characteristics with job demands, but may also give some insight into the ways in which different people resolve similar kinds of problems.

Before such an investigation could take place however, the research staff wanted to know how reliable heart and respiratory measures were under different conditions for different groups of people. Thus, the project was a combination of basic and applied research.

It is hoped that the findings of this project will stimulate others to explore this area in greater depth to identify the ways in which particular responses are related to industrial efficiency, safety, fatigue and productivity.

The staff is deeply grateful for the support and interest of the Social and Rehabilitation Service and the Insurance Company of North America for making this project possible.

Henry Viscardi, Jr.
President

5

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HAROLD YUKER, Ph.D.

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Hans Krobath, Dpl. TECH
Warren Kropf
Mathew Lee, M.D., M.P.H.
Eileen Mitchell
Arnold A. Mordkoff, Ph.D.
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CONTENTS

MEASUREMENT OF CARDIAC AND RESPIRATORY RESPONSES IN PHYSICALLY DISABLED AND NON-DISABLED GROUPS IN A VARIETY OF PSYCHOLOGICAL AND INDUSTRIAL CONDITIONS

ABSTRACT

Eighty-five subjects (paraplegics, cardiacs and physically normal controls) participated in a study which attempted to examine cardiac and respiratory functioning from several points of view. An attempt was made to observe the extent to which the measures of these responses were reliable from a psychometric point of view; the extent to which the responses varied as a function of the psychological stimulus situation; to see whether or not heart and respiratory functions varied among groups of people whose disabilities involved cardiac and respiratory difficulties; and finally to see whether any of the physiological measures were related to selected demographic and personality characteristics.

Among the results of this study the following are cited. It was suggested that over a one week interval the physiological measures are far less reliable then most psychometric paper and pencil measures. Respiration was discovered to be more reliable than cardiac measures. It was also found that the more dynamic the stimulus situation, the lower the reliability of the physiological measure. No consistent patterns of a relationship between physiological measures and the paper and pencil tests administered was found. The study did indicate that under conditions of submaximal stress the subjects in different disability categories showed differential responses in the disability affected areas.

INTRODUCTION

a. Statement of the Problem

The purpose of the research described herein was to study the cardiovascular and respiratory responses of different groups of disabled individuals to experimental situations representing different kinds and degrees of psychological and industrial stress. The specific issues addressed by the research include:

1. the comparison of patterns of physiological response in individuals whose disabilities are closely related to the measures taken to those whose disabilities are unrelated to the measures and to those who are free of any obvious disability;

2. comparison of the physiological response of the disabled groups to the several experimental tasks in the effort to identify the kinds of psychological and physical tasks placing the greatest demands on the individual and how these are manifested behaviorally and physiologically;

3. the determination of the reliability of physiological and behavioral measures taken from subjects at different times under constant conditions; and, the relation of certain demographic, attitudinal, and personality variables to performance of subjects on each of the experimental tasks.

b. Review of Relevant Literature

The research described here was intended to explore the hypothesis that different groups of disabled individuals will exhibit different patterns of autonomic activity in their performance of tasks which have different behavioral and adaptive requirements.

Three experimental tasks, selected to allow the investigation of three apparently diverse behavioral processes were chosen for study. The experimental tasks were selected partially on the basis of the following four restrictive criteria. First they had to be amenable to concurrent physiological measurement. Second they had to be fairly well studied behaviorally so that the parameters which affected their performance were relatively well understood. Third, some indication should exist, either on the basis of pilot study or the general literature, that consistent patterns of physiological response would be exhibited during the performance of the task. Finally, performance on the tasks should be likely to generate low levels of stress.

The three experimental tasks chosen consisted of responses to presentation of emotional provoking pictorial stimuli, a vocabulary test, and a pursuit rotor task. Thus the first was relatively purely non-verbal emotional, the second was largely intellectual in nature and the final task more purely motor in nature.

The hypothesis of a relation between physiological patterning and disabled classification follows from recent studies of human psychophysiology and can be seen as an elaboration and extension of the phenomena of individual-response and stimulus-response specificity. Individual-response specificity refers to the fact that subjects may exhibit preferred channels of physiological response which are reliable over repeated presentations of the same stimulus or the presentation of different stimuli. Stimulus-response specificity refers to the observation that different stimulus situations may elicit different patterns of autonomic nervous activity which are reliable over groups of subjects studied. In the present study, we will examine the data for the presence of "group-response" specificity, i.e., patterns of physiological activity characteristic of different groups of disabled subjects occurring to both the repeated presentation of the same experimental situation and to a variety of different experimental situations.

The existence of specificity was implied by the discovery of the low correlations existent among autonomic nervous system measures, – far lower than their reliabilities. Both inter-individual correlations, in which the cross-products were taken over subjects, as well as intra-individual correlations, in which the cross-products were taken within a single individual over stimulus occasions or time, were low (Lazarus, Speisman and Mordkoff, 1963). This fact, first documented by Lacey (1959), was used to buttress his argument for the existence of individual-response specificity. Engel (1960) clarified the relationship between individual-response and stimulus-response specificities and pointed out that given the appropriate experimental design (i.e., several subjects measured on several autonomic channels under several experimental conditions) both individual-response and stimulus-response specificity can be obtained so long as neither perfect individual-response or stimulus-response specificity obtains. The phenomenon is basically a statistical one with a trading relationship existent between the amount of individual-response and stimulus-response specificity which may be exhibited. Further, it can be shown that individual-response is analogous to and described by the subjects-by-variables interaction and stimulus-response specificity by the conditions-by-variables interaction in the analysis of variance model which can be applied to these experiments.

In the past few years most of the effort has been directed at the description of individual-response specificities in different groups of subjects or stimulus-response specificities under various conditions (Davis, Buchwald, and Frankman, 1955, Lacey, Kagen, Lacey, and Moss, 1963). The former set of studies are most pertinent to the objectives of the present investigation. These studies essentially compare the physiological responses of different groups of subjects to different experimental situations. Although groups of subjects which are in some ways similar to the disabled subjects studied in the present investigation have sometimes been employed, the foci of these investigations were not upon the study of the disability per se.

For example, Malmo and Shagass (1949) found that subjects with presenting cardiovascular complaints (not necessarily suffering from cardiovascular disease) exhibited greater mean heart rates, mean heart rate variability and median respiratory variability than subjects whose major complaints centered about conditions in their head and neck who in turn exhibited higher levels of muscle potential activity.

In another study of psychosomatic patterns, peptic ulcer patients were found to have higher heart rates than rheumatoid arthritis patients, while no differences were found for galvanic skin response or electromyographic activity in either rest, stress or recovery periods (Williams and Krasnoff, 1964).

The last and most pertinent study was reported by Engel and Bickford (1961) who studied physiological responses of hypertensive and normotensive subjects to a variety of mild stress situations. They found that hypertensive and normotensives did not differ in the degree of individual-response specificity exhibited but that pattern of specificity differed in the two groups. The hypertensive group was more likely to exhibit their maximal activation in blood pressure than were the normotensives. This is precisely the kind of phenomenon which will be explored in greater depth in the disabled groups of the present study.

c. Previous Description of the Setting

Human Resources Center, established in Albertson, Long Island, New York is composed of three coordinated units: Human Resources Research and Training Institute; Human Resources School and Abilities Inc.

Human Resources Research and Training Institute is a non-profit component conducting research programs in medical electronics, bio-chemistry, bio-engineering, physiology, and psycho-sociology relating to the diagnosis, treatment and rehabilitation of the disabled and mentally retarded. The Institute conducts evaluation and training programs and research related to the education, vocational training, rehabilitation and employment of the disabled and retarded. Facilities include seminar rooms, specialized research laboratories, medical suites, research library, auditorium, classrooms and areas for adaptive physical education and therapeutic recreation.

Human Resources School is a non-profit educational institution chartered by the Board of Regents of the State of New York offering a full academic curriculum for previously homebound children from the pre-school through senior high school level.

Abilities Inc., is a non-profit demonstration industrial and clerical work center providing employment opportunities in glass engraving, data processing, banking services, mechanical assembly, harness and cable assembly, and process packaging. Its handicapped population consists of the severely physically disabled, mentally retarded, and emotionally restored. Abilities, with its industrial and clerical work environment serves as a research and training laboratory in which the population can be evaluated under actual working conditions.

A more complete description of the setting can be found in The Abilities Story (Viscardi, 1967).

METHODOLOGY

Overview of Procedure

The subjects of this study consisted of three groups of disabled individuals -- respiratory-related, cardiac, and paraplegic groups, and one group of normal controls free of any obvious disability and matched to the disabled groups as closely as possible for age and sex. Each subject was first seen by the project medical director, who confirmed the diagnosis and evaluated the subject's suitability for participation in the study.

Each subject was then seen on two occasions by the research staff. On the first occasion he was administered a series of paper-and-pencil devices including a general information sheet, the Mandler-Sarason Test Anxiety Questionnaire, (Sarason and Mandler, 1952) and the Gough Adjective Check List (Gough and Heilbrun, 1965). Electrodes to measure two channels of physiological response, (electrocardiogram and respiration) were attached, transmitter strapped in place and face mask positioned comfortably on the subject and the three experimental tasks were administered. As noted earlier, task 1 involved the presentation of a series of emotionally arousing or emotionally neutral pictorial stimuli, task 2 was a vocabulary test, and task 3 was a pursuit rotor test.

Approximately one week later, the subject was retested. He was first given the Attitudes Toward Disabled Persons Test, form A (Yuker, Block and Younng, 1966). The three experimental tasks were then repeated along with the collection of physiological data. Then a medical history was obtained (Appendix A of this report).

The physiological potentials were transmitted via an integrated telemetry system developed at Human Resources Center and recorded on magnetic tape, (Brouha and Krobath, 1967; Human Resources Center, 1966; Krobath, 1966; Krobath and Reid, 1964; Pessar, Krobath and Yanover, 1962). Subsequently, each subject's record was analyzed by a series of statistical programs in which the analog is converted to digital form and a series of physiological parameters extracted.

Subjects: Selection and Screening

The disabled subjects were drawn from the employment rolls of Abilities Inc. The medical records of the employees were examined, and any subjects who possessed relevant disabling conditions were contacted for possible testing. The diagnoses were then confirmed by the study physician.

The paraplegic group consisted of subjects whose conditions were either traumatic, infectious, or congenital. These subjects have, in essence, partial or no use of their lower extremities. Most are wheelchair bound. There were 24 subjects in this group, consisting of 17 males and seven females. The ages of the males ranged from 21 to 61 years, and of the females from 23 to 48 years.

For the respiratory-related group we were primarily interested in emphysema and individuals suffering from chronic asthma. We were only able to locate two emphysema patients who could participate in the study and one subject with chronic obstructive pulmonary disease. The use of the face mask to measure respiration was particularly traumatic for those subjects. Due to the small sample, the respiratory-related group was omitted from analyses of group comparisons.

The 10 subjects in the cardiac group were those who had experiences in myocardial infarcts, rheumatic fever, or were diagnosed hypertensive. Five of the subjects have experienced infarcts, 2 were hypertensive, while the remaining three possessed various conditions resulting from rheumatic fever. The cardiac group was all male, with an age range of from 39 to 64 years.

The control group consisted of 51 subjects drawn from Abilities Inc. and Human Resources Center. This experimental group was made up of 38 males and 13 females. The ages of the males ranged from 18 to 69 years, and of the females from 19 to 59 years.

Assessment Devices

On session one the subject was administered three assessment devices, a general information sheet, the Mandler-Sarason Test Anxiety Questionnaire and the Gough Adjective Check List. The general information sheet, in addition to information needed for administration and clerical purposes, included items of demographic nature. (A copy of this form is included in Appendix A of this report). From the responses, the subjects were coded as to sex, age in years, years of education and birth order (first borns and only children versus all others).

The Test Anxiety Questionnaire (Sarason and Mandler, 1952) is a self-administered questionnaire consisting of 39 items intended to measure the subject's apprehensiveness and anxiety towards the upcoming testing situation. The TAQ was administered and scored in its standardized form.

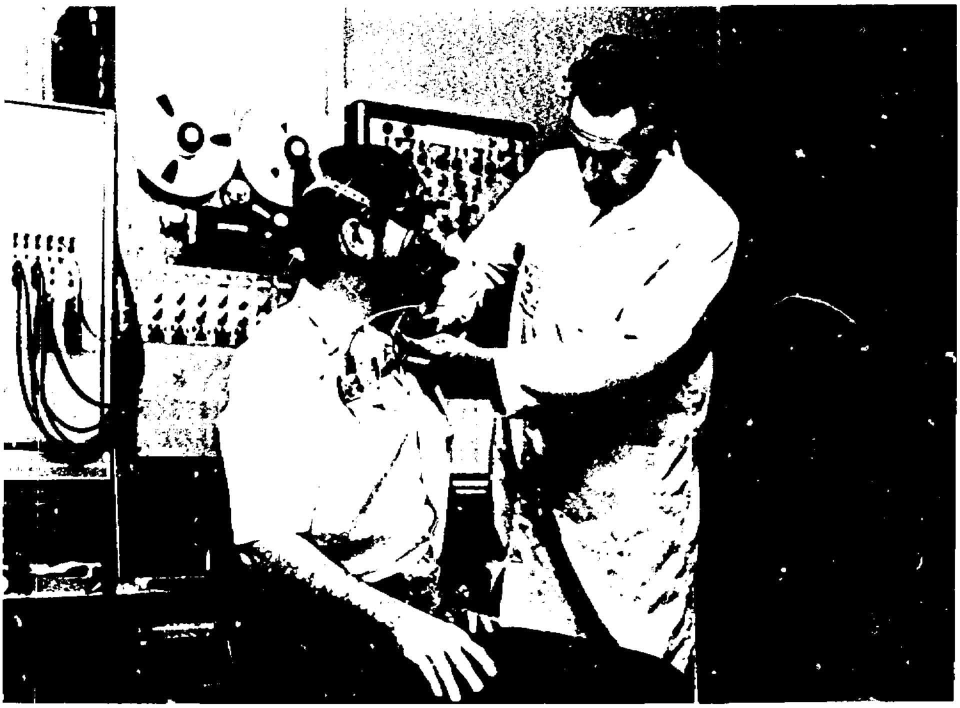
A second measure of attitude toward the testing situation was obtained from the Gough Adjective Check List (Gough and Heilbrun, 1965). Although potentially scoreable for other psychological dimensions, we restricted our attention and use of the ACL to the measurement of the need for achievement. Adjectives such as aggressive, ambitious, capable, industrious, planful, etc. contributed positively to the need achievement score while adjectives such as apathetic, irresponsible, leisurely, etc. contributed in the negative direction. The raw scores were first converted to appropriate standardized T-scores, corrected for the number of adjectives checked according to the tables given by Gough (1965) prior to the analysis.

The medical history (Appendix A) was used to ascertain certain family history data including age, health or cause of death of parents and siblings and personal history information concerning whether the S had had any of 22 common diseases and the ages at which he had the disease. The history also contained a check list of 25 symptons which could be associated with various kinds of medical conditions and inquired as to any hospitalizations or surgical procedures.

Physiological Recording

A major component of the instrumentation employed in the present research was developed at Human Resources under a previous VRA grant This consists of an integrated telemetry system capable of recording, transmitting and receiving electrophysiological data associated with several physiological functions. In the present study it was used in connection with the recording of EKG for the measurement of heart rate and respiration.

The transmitter is the basic unit worn by the subject. It is a plastic-covered box roughly the size of a package of regular cigarettes. It weighs six ounces, and is 3" in length, 1.7" in width and .7" in depth. Within these small dimensions are eight stages, each of which contain over 60 components. The package, as a whole, consists of pre-amplifiers, amplifiers, conditioning amplifiers, a commutator, modulator, and a transmitter. The total unit is comfortably strapped onto the left shoulder of a subject in a position which does not interfere with normal arm movements. Under the present power restrictions, the apparatus can transmit information by radio over distances of one mile with minimal interference. Power is supplied by a 1.3 volt mercury battery with a 500 milliampere hour-life rating. The transmitter, a frequency modulated device, operates on a carrier frequency of 108.2 megacycles. The oscillator for producing this carrier frequency is contained within the transmitter package.



Face mask and transmitter are positioned on subject. Leads from EKG electrodes may be seen emerging from the subject's shirt.

The main receiving station consists of an FM receiver suitable for receiving the 108.2 magacycle frequency, a pulse-weight discriminator, an amplifier, a decommutator, and a differential amplifier following the decommutator.

The FM receiver used at Human Resources is a commercial (Fischer) wide band multiplex tuner which has sensitivity sufficient to provide for accurate detection and processing of the physiological information. Conversion of the frequency modulated signal is accomplished by a discriminator in the receiver. The discriminator produces an amplitude modulated signal which is inversely related to the frequency variations received. That is, the lower the input frequency, the higher the derived output amplitude. The so-called "pulse height" of the output is therefore a function of the original frequencies which were imposed on the carrier wave by the modulator in the process of transmission. The remaining stages of the receiver serve to reverse the processes which occurred in the transmission of the data, namely, to return these signals to the state in which they were originally detected by the body sensors and make them suitable for computer processing. These telemetered signals are then fed into the computer and recorded on magnetic tape for subsequent processing.

Professional staff members and research assistants monitor telemetering equipment in the laboratory.

Task Conditions

a. Emotion Provoking Pictures

A set of 20 pictures of adults and children were prepared on 35 mm. color slides. While all of the persons in the pictures were physically disabled, it was assumed that those pictures of the more severely physically disabled might generate some level of emotion in the subject viewing them.

Pictures were projected on a screen approximately six feet from the subject, in a darkened room. Pictures were shown for a period of 20 seconds, followed by a ten second period of darkness. The type of projector used was a Kodak Carousel 650. The same set of pictures was used for both day one and two.

This task was assumed to be a non-intellectual low level stress task when the pictures of the visibly disabled persons were shown.

b. Vocabulary Test

The vocabulary test consisted of a set of 30 vocabulary items drawn from the Vocabulary GT Series Tests published by Columbia University. These items were also prepared on 35 mm. slides and placed in random order so that some relatively difficult and easy items were interspersed throughout the series. Items were projected on a screen at a distance of approximately six feet from the subject, using the same projector.

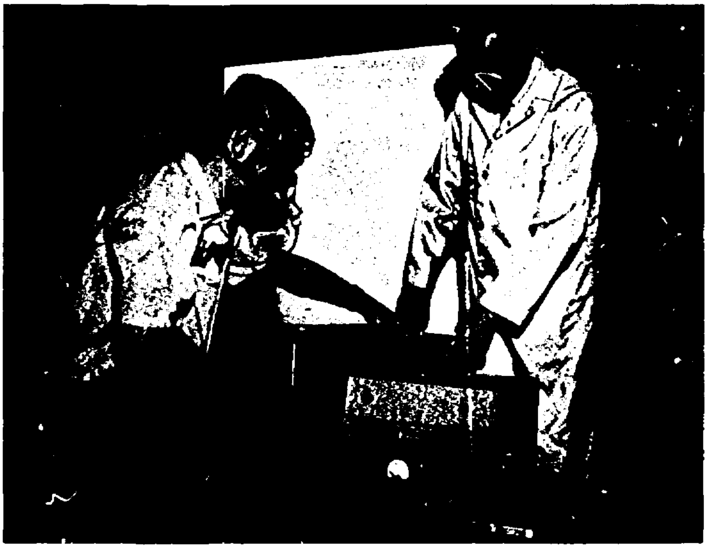
Each item was displayed for 30 seconds followed by a 10 second period during which the subject was asked to circle the correct answer on an answer sheet provided, and indicate whether or not he was confident that the answer was correct. The second testing session involved a different but equivalent set of 30 vocabulary words.

This was presumed to be a relatively more intellectual stress producing task when the "difficult" items were on, and/or when the subject reported he was not "confident" in his response.

c. Pursuit Rotor Test

The pursuit rotor used in the study was a Polar Pursuit Tracker (Research Media, Inc.). The subject's task was to trace a circular line keeping his stylus in touch with a light moving in a clockwise direction at rates of 35 and 70 revolutions per minute in a counterbalanced pattern of trials. There was a 30 second work period followed by a 15 second rest period. This pattern was repeated 20 times.

This was thought to be a non-intellectual motor stress producing task with the assumption being that the subject was under stress when he was off target.



The subject is instructed before administration of pursuit rotor task.

Testing Procedure

From the moment the S entered the lab and throughout the testing session, the Es attempted to create and maintain a neutral, relaxed atmosphere. The S was first administered the Mandler-Sarason Test Anxiety Questionnaire, and was given as much time as he needed to complete the items. Then he was asked to fill out a general information sheet. The third paper-and-pencil measure given was the Gough Adjective Check List. After completion of the ACL, electrodes to measure electrocardiographic responses were placed on the S's chest (Lead V-4). The transmitter was strapped in place and the face mask positioned comfortably on the subject. The room was then darkened and the following instructions read:

"The entire session will take approximately sixty minutes from this point. During this time we must ask you to refrain from talking as much as possible. If you have any questions you may ask them now. If at any time the telemetry equipment becomes uncomfortable or you notice anything wrong, please raise your hand and I will take the appropriate action. Relax for a few minutes while we complete the testing of our equipment and receiver. We will begin in a short while."

E then left the room and a waiting period of irregular length was commenced until the S's heart rate achieved a stable basal level. At this point the necessary information was typed into the computer and the trigger level set. The analog recording was commenced and the signal checked for good transmission. A three minute basal recording of physiological activity was made.

The E then entered the testing room and read the following instructions to the S:

"We are going to show you a series of photographic slides depicting boys and girls from our school and people who work in our factory. While you are looking at each slide try to decide whether or not the slide appeals to you. After the experiment we will ask you which slides did appeal to you and which did not and briefly to describe some of them. After each picture the screen will remain blank for a short period of time. Try to relax during this time. We will show the first slide in three minutes."

Twenty slides were then presented to the S, each exposed for 20 seconds, with ten seconds between slides. On the basis of pilot data, and ratings of the research staff of the emotional provocativeness of the total stimulus pool, the 20 slides consisted of 10 neutral and 10 emotional stimuli.

As soon as the last picture was cycled the picture carousel was removed and the appropriate vocabulary carousel was placed on the projector. The following instructions were read:

"This task will be a vocabulary test. Each word will be projected on the screen in front of you for 30 seconds. Look at the sample word; you will find a main word at the top followed by five words or phrases. For each main word, such as CAT in the sample, you are to select the word or phrase which is most closely associated with, or related to the main word. For the sample the answer ANIMAL would be the correct one. After each word, there will be a short pause during which the screen will remain blank. At this time you are to circle the letter of your choice on your answer sheet, making sure that the number of the word shown corresponds with the number on your answer sheet. Since there is no penalty for wrong answers, you are required to answer all items to the best of your ability.

If you are confident that the choice you have made is correct, place a check on the line to the right of your answer. Please check only if you are confident.

Please make sure that you answer every item at the correct location on your answer sheet. Remember to answer after the screen has gone blank. We will begin in three minutes."

The vocabulary test consisted of thirty items. Two parallel forms of the test were constructed on the basis of pilot dat. Each parallel form consisted of thirty items matched for difficulty, and included both relatively easy and difficult items. Each item was projected on the screen for 30 seconds, an interval determined on the basis of pilot results to be of long enough duration for the subject to select his answer. The S had 10 seconds between items for marking the answer sheet.

After the last answer was completed the projector was turned off and the subject was asked to move to the pursuit rotor. The following instructions were then read:

"This task is the pursuit rotor. It is a tracking task used to study the development of a perceptual-motor skill. The idea is to follow a rotating stimulus, in this case a light, with the stylus. The object is to keep the stylus on the light as it moves around a circular path. When you are on target, the red light will glow. Keep it glowing for as long and as continuously as you can. You can use whichever hand you prefer, but once you begin don't change hands. During the experiment you will have twenty 30 second work periods interspaced with twenty 15 second rest periods. During the rest periods keep the stylus in the center of the circle. Try a sample trial now."

Experimenter pushes the button and the rotor revolves at a speed of 50 rpm.

E then says:

"Good. That's the idea. We'll begin in three minutes."

The twenty test trials which followed were divided evenly between ten fast (70rpm) and ten slow (35 rpm) trials.

After the last work trial the overhead light was turned on, and the t nsmitter, face mask and electrodes removed from the S.

The second session, one week later at the same time of day, consisted of the same procedure. It differed from the first only in that the ATDP (form A) was the sole paper-and-pencil test administered to the S prior to the testing session; form II of the vocabulary items was shown; and a medical history form was filled out by the S after the completion of the pursuit rotor task.

The telemetry testing laboratory at Human Resources Center. The projector with slide carousel, screen and pursuit rotor are in position.

Computer Programming and Data Reduction

Data reduction and analysis was accomplished in two phases. Phase one concerned the series of computer programs and analysis accomplished at Human Resources and related to the determination of intra-individual parameters and analyses. Phase two of the programming was the inter-individual analyses performed on the CDC computer at Courant Institute of New York University.

Phase one analyses performed at Human Resources center consisted of two series of programs. Series one programs were designed to be performed on-line while the actual experimental data was being collected, but could be, and was, deferred to off-line analysis when, for any reason, the computer at Human Resources was not available. Series I programs performed the basic analog to digital conversion of the various parameters of the EKG and respiration data and computed the physiological measures which characterized activity on any particular experimental trial. A trial consisted, for example, of the physiological response to a particular vocabulary item, a single pictorial item, or a single pursuit rotor attempt.

On the vocabulary test, the parameters analyzed correct versus incorrect items, confident versus non-confident items, pre-stimulus heart rate, mean heart rate during each item, maximum heart rate during each item, minimum heart rate, heart rate change (maximum-minimum), the ratio of respiration inspiration time to total cycle time for each item, and the ratio of inspiration volume to total cycle volume for each item.

A series of analyses of covariances were also performed on each of the above physiological parameters with the pre-stimulus values serving as covariants. These analyses yield essentially the same information as t-tests, but the measures are adjusted foı differences in pre-stimulus levels where appropriate. The adjusted values in the following tables refer to the covariance adjusted means.

A similar set of analyses were performed for the emotion provoking pictures test, the major difference examined being that between emotional and neutral stimuli with respect to the above physiological measures. Both t-tests and analyses of covariance were performed on the data of each individual.

On the pursuit rotor test, from the 20 trials, the 8 most accurate and the 8 least accurate trials were selected and same analysis, both t-test and analysis of covariance were performed on the physiological responses.

Serie ? programs were more statistical in nature and analyzed the performance of an individual subject with respect to series of selected trials, e.g. those vocabulary items that the subject responded to correctly, and evaluated the significance of the differences of selected intra-individual comparison, e.g. physiological response to correct vocabulary items compared to that of incorrect items.

RESULTS AND DISCUSSION

Reliability

One of the purposes of the present research was to evaluate the reliability of the various physiological and behavioral measures obtained during the several experimental tasks. Although it would have been of interest to compare the reliabilities obtained above in the different subject groups, the presence of small N's prevented us from making meaningful comparisons. Thus in the following analysis all the subjects were pooled in the determination of reliability. (Normative tables of the mean values, standard deviations and sample sizes for each measure and task condition are presented in Appendix B.)

Vocabulary Test

Each of the parameters obtained from the series 2 programs of Human Resources were correlated over the two occasions of testing. Since in several instances for specific subjects certain measures were not obtainable, we used a missing data correlational program to maximize the sample size for any specific determination of the correlation. The sample size for the correlation coefficients ranged from 60 to 88 resulting in any value of r ranging from .25 to .21 being significant at the .05 level. The results of the correlational analysis are given in Table 1.

In general the results of the correlational analysis allow us to sort the variables into three groups, the behavioral measures, the heart measures, and the respiration measures. The behavioral measures, (the first 4 variables), all show high reliabilities; the cardiovascular variables evidence low if not mainly insignificant, reliabilities; while the respiration measures achieve uniformly high reliabilities.

On the vocabulary test, the only exception to the uniformly low reliabilities evidenced by the heart variables are minimum heart rates which achieve significant levels. When these minimum heart rates are corrected for differences in base levels, the significant correlations are eliminated. With respect to heart rate variables, corrections for differences in initial level generally tend to lower the reliability of the measures. The only exception to these was heart rate change scores, which are, on the average, not changed when adjusted for differences among subjects in initial levels.

Table 1

Vocabulary: Reliability of Behavioral and Physiological Measures

Measures		Reliabilities
# Conect		.79
# Confident		.72
# Correct and Confident		.70
Pre-Stimulus Heart Rates:	Correct Item	.19
Pre-Stimulus Heart Rates:	Incorrect Item	.14

Measures		Reliabilities
Pre-Stimulus Heart Rates:	Confident Item	.13
Pre-Stimulus Heart Rates:	Not Confident Item	.14
Mean Heart Rate:	Correct Item	.24
Mean Heart Rate:	Incorrect Item	.21
Mean Heart Rate:	Confident Item	.19
Mean Heart Rate:	Not Confident Item	.26
Adjusted Mean Heart Rate:	Correct Item	–.04
Adjusted Mean Heart Rate:	Incorrect Item	–.11
Adjusted Mean Heart Rate:	Confident Item	.04
Adjusted Mean Heart Rate:	Not Confident Item	.02
Maximum Heart Rate:	Correct Item	.22
Maximum Heart Rate:	Incorrect Item	.15
Maximum Heart Rate:	Confident Item	.18
Maximum Heart Rate:	Not Confident Item	.13
Adjusted Maximum Heart Rate:	Correct Item	.20
Adjusted Maximum Heart Rate:	Incorrect Item	.13
Adjusted Maximum Heart Rate:	Confident Item	.13
Adjusted Maximum Heart Rate:	Not Confident Item	.14
Minimum Heart Rates:	Correct Item	.52
Minimum Heart Rates:	Incorrect Item	.61
Minimum Heart Rates:	Confident Item	.49
Minimum Heart Rates:	Not Confident Item	.46
Adjusted Minimum Heart Rates:	Correct Item	.17
Adjusted Minimum Heart Rates:	Incorrect Item	.12
Adjusted Minimum Heart Rates:	Confident Item	.13

Measures		Reliabilities
Adjusted Minimum Heart Rates:	Not Confident Item	.13
Heart Rate Changes (Max.-Min.)	Correct Item	.10
Heart Rate Changes (Max.-Min.)	Incorrect Item	.02
Heart Rate Changes (Max.-Min.)	Confident Item	.28
Heart Rate Changes (Max.-Min.)	Not Confident Item	.28
Adjusted Heart Rate Changes (Max.-Min.)	Correct Item	.19
Adjusted Heart Rate Changes (Max.-Min.)	Incorrect Item	.14
Adjusted Heart Rate Changes (Max.-Min.)	Confident Item	.13
Adjusted Heart Rate Changes (Max.-Min.)	Not Confident Item	.14
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Correct Item	.59
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.39
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.68
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.53
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.55
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.59
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.50
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Not Confident Item	.63
Respiration: Stimulus Inspiration Time/Total Cycle Time	Correct Item	.63
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.67
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.67

Measures		Reliabilities
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.64
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Correct Item	.64
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.44
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.69
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.48
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.61
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.56
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.63
Respiration: Stimulus Inspiration Volume/Total Cycle Volume	Not Confident Item	.60
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.51
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.56
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.57
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Not Confident Item	.60

Emotion Provoking Pictures Test

Only physiological response measures were obtained from the EPPT. As with the vocabulary test, Pearson product-moment correlation coefficients were obtained for each of the measures between the two occasions of testing. Again, a missing data program was utilized to maximize the N for any particular comparison The results of the analyses are given in Table 2.

The difference between the reliabilities of the heart rate and respiration variables which obtained for the vocabulary test is not as clearly in evidence for the EPPT. Although, on the average, the magnitudes of coeffieients for the heart rate variables appear to be lower than that for the respiration variables, the difference is not nearly as substantial as that obtained for the Vocabulary Test. The heart rate variables which now show atypically low reliabilities are those for maximum heart rate and heart rate change. When the maximum heart rates are adjusted via a covariance analysis for differences among subjects in pre-stimulus levels, the reliabilities achieve values comparable to the other heart rate measures. Adjustment of the heart rate changes is not nearly so successful in incrementing their reliabilities. It appears that heart rate range during a trial may be intrinsically the least stable index of cardiovascular activity under these testing conditions.

Again the various indices of respiration show substantial reliability over the two occasions of testing. The magnitudes of the observed reliabilities are comparable to those found for the Vocabulary Test. No significant differences are observed in the magnitudes of the coefficients for the time versus the volume measures.

Table 2

Pictures: Reliability of Physiological Measures

asures		Reliabilities
Pre-Stimulus Mean Heart Rate:	Emotional Stimuli	.50
Pre-Stimulus Mean Heart Rate:	Neutral Stimuli	.30
Stimulus Mean Heart Rate:	Emotional Stimuli	.45
Stimulus Mean Heart Rate:	Neutral Stimuli	.45
Adjusted Stimulus Mean Heart Rate:	Emotional Stimuli	.34
Adjusted Stimulus Mean Heart Rate:	Neutral Stimuli	.30
Maximum Heart Rate:	Emotional Stimuli	.07
Maximum Heart Rate:	Neutral Stimuli	.08
Adjusted Maximum Heart Rate:	Emotional Stimuli	.43
Adjusted Maximum Heart Rate:	Neutral Stimuli	.39
Minimum Heart Rate:	Emotional Stimuli	.40
Minimum Heart Rate:	Neutral Stimuli	.41
Adjusted Minimum Heart Rate:	Emotional Stimuli	.44
Adjusted Minimum Heart Rate:	Neutral Stimuli	.40
Heart Rate Changes (Max.-Min.)	Emotional Stimuli	–.13

Measures		Reliabilities
Heart Rate Changes (Max.-Min.)	Neutral Stimuli	–.10
Adjusted Heart Rate Changes (Max.-Min.)	Emotional Stimuli	–.39
Adjusted Heart Rate Changes (Max.–Min.)	Neutral Stimuli	.20
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time	Emotional Stimuli	.54
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time	Neutral Stimuli	.43
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume	Emotional Stimuli	.52
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume	Neutral Stimuli	.38
Respiration: Stimulus Inspiration Time/Total Cycle Time	Emotional Stimuli	.55
Respiration: Stimulus Inspiration Time/Total Cycle Time	Neutral Stimuli	.59
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time	Emotional Stimuli	.47
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time	Neutral Stimuli	.38
Respiration: Stimulus Inspiration Volume/Total Cycle Volume	Emotional Stimuli	.64
Respiration: Stimulus Inspiration Volume/Total Cycle Volume	Neutral Stimuli	.51
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume	Emotional Stimuli	.37
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume	Neutral Stimuli	.33

Pursuit Rotor Task

The pattern of the reliabilities for the pursuit rotor task given in Table 3 resembles that obtained for vocabulary to a greater degree than was observed for Emotion Provoking Pictures Test

Although some of the heart rate measures evidence fairly substantial reliabilities, they are quite variable and on the average much lower than the respiration measures. The pattern of the heart rate reliabilities in those few cases where substantial reliabilities are observed is also difficult to interpret. Often it appears to be the case that reliabilities are higher for the trials where more accurate performance was observed than on trials when inaccurate performance occurred. Adjustments for differences in pre-trial heart rates has variable effects, sometimes increasing the reliability as in the case of mean heart rate on accurate trials, and sometimes decreasing the reliability substantially as in maximum heart rate on accurate trials. In general the pattern of reliabilities for heart rate is fairly unpredictable.

Respiration, on the other hand, shows consistent and high reliabilities for both time and volume measures on both accurate and inaccurate trials. There seems to be some tendency for the reliability on accurate trials to exceed that on inaccurate trials, but the difference is not substantial. Similarly, there appears to be a tendency for volume measures to have slightly greater reliabilities than respiration cycle time indices, but again the difference between them does not appear to be substantial and does not have much practical significance.

Table 3

Pursuit Rotor: Reliability of Physiological Measures

Measures		Reliabilities
Pre-trial Mean Heart Rate:	Accurate	.45
Pre-trial Mean Heart Rate:	Inaccurate	.03
Trial Mean Heart Rate:	Accurate	.24
Trial Mean Heart Rate:	Inaccurate	.14
Adjusted Trial Mean Heart Rate:	Accurate	.42
Adjusted Trial Mean Heart Rate:	Inaccurate	.06
Trial Maximum Heart Rate:	Accurate	.49
Trial Maximum Heart Rate:	Inaccurate	.35
Adjusted Trial Maximum Heart Rate:	Accurate	−.01
Adjusted Trial Maximum Heart Rate:	Inaccurate	−.06
Trial Minimum Heart Rate:	Accurate	.59
Trial Minimum Heart Rate:	Inaccurate	.08
Adjusted Trial Minimum Heart Rate:	Accurate	.40
Adjusted Trial Minimum Heart Rate:	Inaccurate	.05

Measures		Reliabilities
Heart Rate Change (Max.-Min.)	Accurate	.45
Heart Rate Change (Max.-Min.)	Inaccurate	.27
Adjusted Heart Rate Change (Max.-Min.)	Accurate	.30
Adjusted Heart Rate Change (Max.-Min.)	Inaccurate	−.08
Respiration: Pre-Trial Inspiration Time/Total Cycle Time:	Accurate	.45
Respiration: Pre-Trial Inspiration Time/Total Cycle Time:	Inaccurate	.47
Respiration: Pre-Trial Inspiration Volume/Total Cycle Volume:	Accurate	.52
Respiration: Pre-Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.48
Respiration: Trial Inspiration Time/Total Cycle Time:	Accurate	.55
Respiration: Trial Inspiration Time/Total Cycle Time:	Inaccurate	.34
Respiration: Adjusted Trial Inspiration Time/Total Cycle Time:	Accurate	.46
Respiration: Adjusted Trial Inspiration Time/Total Cycle Time:	Inaccurate	.46
Respiration: Trial Inspiration Volume/Total Cycle Volume:	Accurate	.67
Respiration: Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.59
Respiration: Adjusted Trial Inspiration Volume/Total Cycle Volume:	Accurate	.54
Respiration: Adjusted Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.39

Discussion – Reliability

The results of the investigation of the reliabilities of the various physiological response measures to the several experimental situations allow us to make several generalizations. First, the respiratory measures appear in general to be more reliable than the cardiovascular response measures. Second, the experimental tasks which involve more activity on the part of the subject are the ones in which the lowest cardiovascular reliability occurred. The Emotion Provoking Pictures Test which demands only that the subject view slides of either high or low emotionality was the only task during which the cardiovascular measures evidenced reasonably high levels of reliability. On both the pursuit rotor task, in which the subject is engaged in complex skeletal motor coordinations, and the vocabulary task, in which the activity demanded of the subject is mainly of an intellectual nature, the cardiovascular measures were of low reliability. Few experimental investigations evaluate in a psychometric sense the reliability of their dependent measures. The low reliability of the cardiovascular measures especially in the pursuit rotor and vocabulary cannot but affect the ability of these measures to generate significant effects in other contexts, e.g., when we analyze those measures for differences among our subject groups. Our interpretation of the results of the group differences should take into account the differential reliability of the physiological measures in relation to the particular tasks involved.

Group Differences

The second major purpose of the present study was to investigate differences among our disabled groups in physiological function during each of the experimental tasks. The general hypothesis guiding the investigation was that each of the disabled groups would be more responsive in the physiological function related to their disability. Hence the cardiac group would evidence more indication of stress to the experimental tasks in cardiovascular activity, while the response of the paraplegics and control groups should be more a function of the task requirements. To investigate this general hypothesis, the behavior and physiological response measures obtained as output from the Series 2 programs of Human Resources were treated to one analysis of variance, the major dimension investigated being the subject classification into either controls, cardiacs or paraplegics.

Assessment Variables

The major purpose of the assessment variables in the present analysis was to be related to the evaluation of individual differences in performance to the several experimental tasks. We intended to match the several patient groups on many of these parameters. Since we were not able to achieve relatively balanced subject groups, the analysis of the assessment variables takes on some interest and relevance in order to evaluate the comparability of the subject groups on these demographic and psychological dimensions.

Each of the assessment variables were appropriately coded and then treated to analysis of variance. Only one of them, years of education, was significant. The results of the analysis are given in Table 4.

The cardiac group had significantly less education than either of the other two groups, the cardiac group averaging about 10 years of education, the other groups exceeding 12 years. This difference was significant at the .01 level of significance. On the other assessment variables relating to age, birth order, test anxiety, and attitudes towards disability, the three experimental groups showed no tendency to differ from one another.

Table 4

Summary of Analysis of Variance of Years of Education

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	38.9	19.5	4.82
Within	82	330.9	4.0	
Total	84	369.8		

Means and Standard Deviations

Group	Mean	S.D.
Control	12.3	2.0
Cardiac	10.2	2.0
Paraplegic	12.2	2.0

Vocabulary Test

There were three behavioral measures obtained from the vocabulary test: the number of items correct, the number of items on which the subject was confident, and the coefficient of concordance between the items to which the subject was both correct and confident. These measures gave rise to some significant differences on either the first or second testing. On the second testing the cardiac group obtained a significantly lower number of correct items. The results of this analysis are given in Table 5.

Table 5

Summary of Analysis of Variance of # Correct Items: Vocabulary Test, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	149.5	74.7	4.41
Within	65	1099.5	16.9	
Total	67	1249.0		

Means and Standard Deviations

Group	Mean	S.D.
Control	17.7	3.6
Cardiac	13.6	5.0
Paraplegic	15.6	4.4

Out of thirty items, the cardiac group got slightly more than 13 correct while the paraplegic group averaged more than 15 and the controls over 17. The same tendency was evidenced on Test Day 1, but the differences there did not achieve significance. The results for the analysis of day 1 are given in Table 6.

Table 6

Summary of Analysis of Variance of # Correct Items. Vocabulary Test, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	102.4	51.2	3.03
Within	77	1301.4	16.9	
Total	79	1403.8		

Means and Standard Deviations

Group	Mean	S.D.
Control	17.0	3.9
Cardiac	13.3	5.0
Paraplegic	16.5	4.2

Looking at the results for both day 1 and day 2 together, it seems to be the case that the cardiac group is scoring lower than either of the other two groups. This might be related to the previously discussed difference among the groups in years of education, the cardiac group there too having fewer years of education. Although these differences exist, they should not affect the interpretation of our more central interest, differences among the groups in physiological response to the vocabulary test.

On day 2, the groups differed in a similar fashion on the number of items that the subjects were both correct and confident about. The results of this analysis are given in Table 7. These differences which parallel the previous variable are probably due to the aforementioned differences in the number of correct items.

Table 7

Summary of Analysis of Variance of # Correct and Confident: Vocabulary Test, Day 2

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Between	2	176.3	88.2	3.46
Within	65	1655.0	25.4	
Total	67	1831.3		

Means and Standard Deviations

Group	Mean	S.D.
Control	12.1	4.7
Cardiac	7.4	6.8
Paraplegic	10.3	4.8

Given the previously described unreliability in cardiovascular response during the vocabulary test, it is not surprising that none of the cardiovascular measures evidenced any significant tendency to differentiate among the three experimental groups. On the other hand, respiratory function gave rise to a number of significant effects.

The ratio of inspiration time to total cycle time differed among the three groups on the second occasion of testing during the anticipatory period prior to which the stimulus was presented. Although similar patterns were evidenced for both correct and incorrect items, the effect is significant for only the incorrect items. The data is given in Table 8.

The paraplegic group appears to have significantly higher ratios than the other two groups, that is, spend significantly more time, proportionally, in the inspiration phase of their respiratory cycle.

Table 8

Summary of Analysis of Variance of Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time: Incorrect Item, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.083	.042	3.59
Within	65	.753	.012	
Total	67	.836		

Means and Standard Deviations

Group	Mean	S.D.
Control	.37	.10
Cardiac	.38	.12
Paraplegic	.45	.11

The same type of respiratory pattern is observed during the time of exposure to the vocabulary items, that is, the paraplegic group appears to have significantly higher respiratory time ratios than either the cardiac group or the control group. This is evidenced in their response to right items on day 1 (Table 9), right items day 2 (Table 10), wrong items day 1 (Table 11), and wrong items day 2 (Table 12). Although the same pattern emerges in all four analyses, it is significant for only the last three.

The pattern is for the paraplegic group to have significantly higher respiratory time ratios than either of the other groups. Sometimes the cardiac group falls in between the control group and paraplegic group (Table 9) and sometimes the cardiac group evidences the lowest ratio (Tables 10–12).

Table 9

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Correct Items, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.049	.024	2.83
Within	75	.645	.008	
Total	77	.694		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.08
Cardiac	.42	.07
Paraplegic	.47	.13

Table 10

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Correct Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.189	.094	10.97
Within	64	.549	.009	
Total	66	.738		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.07
Cardiac	.32	09
Paraplegic	.49	.13

Table 11

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Incorrect Items, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.053	.027	3.65
Within	75	.546	.008	
Total	77	.599		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.08
Cardiac	.40	.05
Paraplegic	.47	.12

Table 12

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Incorrect Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.12	.061	7.28
Within	64	.54	.008	
Total	66	.66		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.07
Cardiac	.36	.09
Paraplegic	.49	.12

The same pattern of differences is obtained when the vocabulary items are sorted with respect to confident and non-confident items (Tables 13–16).

In each case, the pattern is for the paraplegic group to exhibit higher cycle time ratios than either the cardiac or control groups. This effect is significant for 3 of the analyses (Tables 13, 14, and 16), but the same tendency which just fails to reach significance is evidenced in Table 15, the analysis of the non-confident items on day 1.

Table 13

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Confident Items, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.059	.030	3.54
Within	71	.590	.009	
Total	73	.649		

Means and Standard Deviations

Group	Mean	S.D.
Control	.40	.07
Cardiac	.43	.06
Paraplegic	.47	.12

Table 14

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Confident Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.099	.050	6.02
Within	60	.490	.009	
Total	62	.589		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.07
Cardiac	.40	.06
Paraplegic	.50	.12

Table 15

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Non-Confident Items, Day 1

Souce of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.040	.020	2.67
Within	75	.563	.007	
Total	77	.603		

Means and Standard Deviations

Group	Mean	S.D.
Control	.42	.07
Cardiac	.41	.05
Paraplegic	.47	.11

Table 16

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio:
Non-Confident Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.149	.074	8.52
Within	64	.557	.008	
Total	66	.706		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.07
Cardiac	.33	.08
Paraplegic	.48	.13

When each of the individual subject's respiratory responses during the stimulus are adjusted for differences which existed prior to the presentation of stimulus using the analysis of covariance procedure, the same pattern previously described persists and implies that all of the above differences in respiratory pattern to the presentation of the vocabulary items cannot be accounted for on the basis of pre-existing response tendencies. Analyses of variance, however, show that this difference is significant only on day 2 for both correct and incorrent items. The results of these analyses are given in Tables 17 and 18.

After correction for differences among the groups in initial or pre-stimulus respiration cycle time ratios, the paraplegic group still evidences significantly higher ratios to both correct and incorrect items. The position of the cardiac group is still inconsistent. With respect to the correct items they fall on the low end of the scale, even lower in ratio than the control group. On the incorrect items their scores are virtually identical with the control group. In general, we might conclude that with respect to the ratio of the inspiration cycle time to total cycle time, the major effects are due to the performance of the paraplegic group who evidence in both pre-stimulus and stimulus times an increased amount of time spent proportionally in the inspiration phase of respiratory activity.

Table 17

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Correct Items, Day 2

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Between	2	.088	.043	3.89
Within	64	.719	.011	
Total	66	.807		

Means and Standard Deviations

Group	Mean	S.D.
Control	.39	.09
Cardiac	.33	.12
Paraplegic	.44	.11

Table 18

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Incorrect Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.070	.036	3.37
Within	64	.667	.010	
Total	66	.737		

Means and Standard Deviations

Group	Mean	S.D.
Control	.38	.09
Cardiac	.38	.12
Paraplegic	.44	.11

The results for respiratory cycle volume are not nearly as striking as those described above for respiratory cycle time. There was some tendency for the paraplegic group to exhibit greater inspiration-respiration respiratory volume ratios on day 2 to both correct and incorrect items, but the differences among the groups do not achieve standard levels of significance (Tables 19 and 20).

Table 19

Summary of Analysis of Variance of Stimulus Inspiration Volume Ratio:
Correct Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.10	.050	3.03
Within	64	1.07	.017	
Total	66	1.17		

Means and Standard Deviations

Group	Mean	S.D.
Control	.48	.09
Cardiac	.38	.15
Paraplegic	.50	.17

Table 20

Summary of Analysis of Variance of Stimulus Inspiration Volume Ratio:
Incorrect Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.09	.049	3.07
Within	64	1.03	.016	
Total	66	1.12		

Means and Standard Deviations

Group	Mean	S.D.
Control	.48	.09
Cardiac	.39	.11
Paraplegic	.51	.17

When adjusted for differences among the groups in initial levels, respiratory volume does reach significance for the right items on day 2, but the resulting hierarchy of the groups is unexpected and not consistent with the previously reported data for respiratory cycle time (Table 21).

When we examine the adjusted means, we find that now the deviant group, in the sense that they are least like the control group, is the cardiac group which exhibits substantially reduced respiratory volume ratios as compared to the controls and the paraplegics. We find that when we examined the comparable data for respiratory time (Table 17), the same pattern was in evidence there but since it was not consistent on other days or with other parameters, it was not overtly interpreted. Examining the other respiratory volume tables reveals the same kind of variability in the positioning of the cardiac group that we found for respiratory cycle time, so that over-interpretation of this particular effect for respiratory volume would not seem to be appropriate.

Table 21

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Volume Ratio: Correct Items, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.09	.049	3.33
Within	65	.95	.014	
Total	67	1.04		

Means and Standard Deviations

Group	Mean	S.D.
Control	.47	.09
Cardiac	.36	.14
Paraplegic	.48	.14

Emotion Provoking Pictures Test

On the emotion provoking pictures test, all that was required of the subject was that he view actively the stimuli being presented. The same physiological response measures described in connection with the vocabulary test were obtained during this procedure. No behavioral measures were taken.

For each subject, the average heart rate response to the emotional and neutral stimuli was computed and the "t" value representing the extent to which the subjects discriminated in their heart rates between emotional and neutral stimuli obtained. These t values were then treated to analysis of variance. The results of this analysis given in Table 22 indicate that the cardiac group discriminated in their heart rates between the emotional and neutral stimuli to a far greater degree than did the other two groups. This tendency is present on both day 1 and 2 but significant for only day 1. The same effect exhibited by average heart rate is shown by maximum heart rates on both day 1 and 2.

Table 22

Summary of Analysis of Variance of T-Values, Stimulus Mean Heart Rates, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	10.0	5.01	9.43
Within	77	40.9	.53	
Total	79	50.9		

Means and Standard Deviations

Group	Mean	S.D.
Control	.94	.62
Cardiac	2.18	1.42
Paraplegic	.88	.67

But as can be seen in Tables 23 and 24, different patterns occur on the two days of testing.

On day 1, the cardiacs exhibit the greatest differentiation between emotional and neutral stimuli as shown by their significantly higher t values. But on day 2, the cardiacs' heart rate differentiation appears to have dampened out, and the paraplegic group exhibits significantly higher t values.

Table 23

Summary of Analysis of Variance of F values, Stimulus Maximum Heart Rate, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	3.07	1.53	4.04
Within	77	29.26	.38	
Total	79	32.33		

Means and Standard Deviations

Group	Mean	S.D.
Control	.96	.61
Cardiac	1.57	.72
Paraplegic	.81	.59

Table 24

Summary of Analysis of Variance of F value, Stimulus Maximum Heart Rates, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	3.3	1.67	4.21
Within	65	25.7	.40	
Total	67	29.0		

Means and Standard Deviations

Group	Mean	S.D.
Control	.79	.56
Cardiac	.52	.48
Paraplegic	1.19	.77

The minimum heart rates exhibit the same pattern on day 1 previously described for mean heart rate and maximum heart rate (Table 25). Thus it appears that all aspects of heart rate: levels, average, maximum and minimum heart rate, on day 1 were significantly more sensitive to the content of the pictorial stimuli in the cardiac group than in the control or paraplegic groups.

Table 25

Summary of Analysis of Variance of F values, Stimulus Minimum Heart Rates, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	5.4	2.73	6.22
Within	77	33.8	.43	
Total	79	39.2		

Means and Standard Deviations

Group	Mean	S.D.
Control	.83	.61
Cardiac	1.77	1.31
Paraplegic	.89	.49

On the other hand, the paraplegic group continues to differentiate itself in respiratory activity. As shown in Table 26–29, the paraplegic group exhibits significantly higher pre-stimulus inspiration cycle time ratios on both day 1 and day 2 to both neutral and emotional stimuli. This effect is significant in all analyses of the pre-stimulus activity except that of neutral stimuli on day 1 where, however, the same pattern is evident. The position of the cardiac group is also consistent in all four analyses, falling below the controls and demonstrating the lowest inspiration cycle time ratios.

Table 26

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Emotional Stimuli, Day 1

Source of Variation	D. F.	Sum of Squares	Mean Square	F
Between	2	.09	.046	3.24
Within	74	1.06	.014	
Total	76	1.15		

Means and Standard Deviations

Group	Mean	S.D.
Control	.36	.10
Cardiac	.34	.11
Paraplegic	.43	.14

Table 27

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Emotional Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.14	.07	4.87
Within	65	.97	.01	
Total	67	1.11		

Means and Standard Deviations

Group	Mean	S.D.
Control	.40	.11
Cardiac	.32	.09
Paraplegic	.47	.14

Table 28

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Neutral Stimuli, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.07	.037	2.59
Within	73	1.04	.014	
Total	75	1.11		

Means and Standard Deviations

Group	Mean	S.D.
Control	.36	.12
Cardiac	.34	.14
Paraplegic	.43	.09

Table 29

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Neutral Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.198	.098	5.59
Within	65	1.148	.017	
Total	67	1.346		

Means and Standard Deviations

Group	Mean	S.D.
Control	.38	.12
Cardiac	.30	.14
Paraplegic	.47	.14

Pre-stimulus respiratory volume ratios exhibit the same pattern as cycle time, but the effect is only significant on day 2 for the neutral stimuli and illustrated in Table 30.

Again, the paraplegic group exhibits the highest inspiration volume to total cycle volume ratios with the cardiacs demonstrating the lowest values and the control group falling in between.

Table 30

Summary of Analysis of Variance of Pre-Stimulus Inspiration Volume Ratio: Neutral Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.178	.088	3.33
Within	65	1.726	.026	
Total	67	1.904		

Means and Standard Deviations

Group	Mean	S.D.
Control	.44	.15
Cardiac	.33	.17
Paraplegic	.51	.18

The same pattern of results obtained during the pre-stimulus interval for respiratory cycle time continues during the presentation of the stimulus. The paraplegic group continues to show the highest inspiration ratios as indicated by Tables 31–34.

The effect is significant for all of the above comparisons except with respect to the neutral stimuli on day 1, where the same pattern is still evident. The position of the cardiac group is, however, more variable during the presentation of the stimulus than it was during the pre-stimulus interval. In two of the analyses they obtain the lowest ratios, as they did during the pre-stimulus period, but in the other two their position is intermediate between the paraplegic group and the control group. Again here, we would conclude that the effects with respect to respiratory ratios seem to be more consistently due to the behavior of the paraplegic group than to the cardiac group or a combination of the two.

Table 31

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Emotional Stimuli, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.059	.029	4.06
Within	77	.561	.007	
Total	79	.620		

Means and Standard Deviations

Group	Mean	S.D.
Control	.42	.07
Cardiac	.43	.10
Paraplegic	.48	.10

Table 32

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Emotional Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.082	.041	3.95
Within	65	.676	.010	
Total	67	.758		

Means and Standard Deviations

Group	Mean	S.D.
Control	.43	.07
Cardiac	.39	.06
Paraplegic	.49	.14

Table 33

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Neutral Stimuli, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.041	.020	2.71
Within	77	.580	.007	
Total	79	.621		

Means and Standard Deviations

Group	Mean	S.D.
Control	.42	.07
Cardiac	.43	.10
Paraplegic	.47	.10

Table 34

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Neutral Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.136	.068	6.89
Within	65	.642	.009	
Total	67	.778		

Means and Standard Deviations

Group	Mean	S.D.
Control	.43	.07
Cardiac	.38	.08
Paraplegic	.51	.13

When the stimulus cycle time ratios are adjusted for the differences among the groups that existed during the pre-stimulus period, the pattern previously described persists but is significant only on day 2. (Tables 35-36).

The paraplegic group continues to exhibit the highest respiratory cycle ratios and, after adjustment, the cardiac group exhibits the lowest.

Although the respiratory volume data parallels the data for respiratory cycle time in the ordering of the three groups, the effects do not reach statistical significance.

Table 35

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Emotional Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.15	.078	5.35
Within	65	.95	.014	
Total	67	1.10		

Means and Standard Deviations

Group	Mean	S.D.
Control	.39	.12
Cardiac	.32	.09
Paraplegic	.47	.13

Table 36

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Neutral Stimuli, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.15	.078	4.90
Within	64	1.02	.016	
Total	66	1.17		

Means and Standard Deviations

Group	Mean	S.D.
Control	.38	.11
Cardiac	.32	.09
Paraplegic	.46	.15

Pursuit Rotor Task

The pursuit rotor task, like the vocabulary test, did not yield substantially reliable heart rate measures and thus we should not expect as consistent heart rate effects to be observed as was the case for the emotion provoking pictures test. This expectation is borne out by the data.

Some significant heart rate effects are observed. For example, consistent differences among the groups were found for heart rate pre-stimulus levels on day 1 accurate trials (Table 37).

Table 37

Summary of Analysis of Variance of Pre-Stimulus Heart Rate: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	1435.5	717.7	3.56
Within	53	10695.7	201.8	
Total	55	12131.2		

Means and Standard Deviations

Group	Mean	S.D.
Control	92.8	17.2
Cardiac	83.2	10.1
Paraplegic	82.2	7.2

As shown in Table 37, the pre-stimulus levels for the control group on the accurate trials were significantly higher than either of the two patient groups. This pattern is not typical for the other pre-stimulus measures taken and the only one to reach significance. The differences among the groups observed on the pre-stimulus periods continue during the pursuit rotor trials themselves with the control group continuing to demonstrate significantly higher average heart rate levels.

It is difficult to make an unequivocal interpretation of these findings. It would appear, however, that when the control group evidences higher heart rates on both the pre-stimulus period or during the actual pursuit rotor trial, it was likely to be more accurate on those trials, whereas in the two disabled groups such differentiation between accurate and inaccurate performance was not made in their heart rate activity.

Table 38

Summary of Analysis of Variance of Adjusted Stimulus Heart Rate: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	1427.09	713.5	3.81
Within	53	9930.01	187.3	
Total	55	11357.10		

Means and Standard Deviations

Group	Mean	S.D.
Control	92.9	16.6
Cardiac	83.9	9.1
Paraplegic	82.2	7.2

The same pattern of performance on these trials is evidenced in the maximum heart rates observed during trials and those maximum heart rates when adjusted for differences between the groups in pre-stimulus level (Table 39). Thus the differences during the pursuit rotor trials cannot be totally accounted for on the basis of pre-stimulus heart rate differences.

Table 39

Summary of Analysis of Variance of Adjusted Stimulus Maximum Heart Rates: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	1918.8	959.4	4.10
Within	53	12404.9	234.0	
Total	55	14323.7		

Means and Standard Deviations

Group	Mean	S.D.
Control	94.6	18.8
Cardiac	84.8	8.6
Paraplegic	81.9	7.4

Parallel results are obtained for minimum heart rate on accurate trials on day 2. The summary of this analysis is given in Table 40.

Table 40

Summary of Analysis of Variance of Adjusted Minimum Heart Rates: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	1633.1	816.5	3.69
Within	53	11738.9	221.4	
Total	55	13372.0		

Means and Standard Deviations

Group	Mean	S.D.
Control	93.8	18.3
Cardiac	83.7	8.9
Paraplegic	82.5	6.9

And finally, contrary to what might be expected from the foregoing results, heart rate range, even after adjustment for differences in pre-stimulus level, is significantly greater for the control group on accurate trials of day 2. Thus both mean level increases and overall variability seem to be associated in the control group but not in the disabled groups with more effective performance on the pursuit rotor task.

Table 41

Summary of Analysis of Variance of Adjusted Heart Rate Range: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	2204.5	1102.2	4.22
Within	52	13596.0	261.4	
Total	54	15800.5		

Means and Standard Deviations

Group	Mean	S.D.
Control	95.1	19.9
Cardiac	83.1	10.4
Paraplegic	81.9	7.4

As might be expected, respiration measures gave rise to a number of significant effects among groups during their performance of the pursuit rotor task. All four pre-stimulus measures of the ratio of inspiration cycle time to total cycle time evidenced significant differences among the groups (Tables 42–45).

As on the previous tasks, the performance of the paraplegic group is the most consistent of the three groups exhibiting significantly higher ratios than the other two groups. The relative standing of the cardiac and control groups is more difficult to interpret. On day 1 analyses, the cardiac group is intermediate between the control and paraplegic groups, while on day 2 the control group is intermediate between the cardiac and paraplegic groups. Hence the most conservative interpretation of these results would attribute the effects observed to the behavior of the paraplegic group who consistently evidence the highest respiration cycle ratios.

Table 42

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Accurate Trials, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.084	.042	3.52
Within	52	.621	.012	
Total	54	.705		

Means and Standard Deviations

Group	Mean	S.D.
Control	.36	.10
Cardiac	.41	.14
Paraplegic	.44	.12

Table 43

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.192	.096	7.70
Within	53	.661	.012	
Total	55	.853		

Means and Standard Deviations

Group	Mean	S.D.
Control	.39	.10
Cardiac	.32	.12
Paraplegic	.49	.12

Table 44

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.094	.047	7.02
Within	53	.356	.006	
Total	55	.450		

Means and Standard Deviations

Group	Mean	S.D.
Control	.37	.07
Cardiac	.39	.14
Paraplegic	.46	.07

Table 45

Summary of Analysis of Variance of Pre-Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.136	.068	6.15
Within	53	.589	.011	
Total	55	.725		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.09
Cardiac	.32	.10
Paraplegic	.48	.11

Parallel results are found for respiration cycle ratio during the pursuit rotor trials (Tables 46–49) with the paraplegic group still continuing to exhibit the highest ratios and the position of the cardiac group varying on day 1 and day 2.

Table 46

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Accurate Trials, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.054	.027	4.94
Within	51	.282	.005	
Total	53	.336		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.05
Cardiac	.40	.12
Paraplegic	.48	.09

Table 47

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.053	.026	3.70
Within	46	.333	.007	
Total	48	.386		

Means and Standard Deviations

Group	Mean	S.D.
Control	.43	.08
Cardiac	.40	.11
Paraplegic	.49	.08

Table 48

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.075	.038	6.32
Within	51	.304	.006	
Total	53	.379		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.06
Cardiac	.45	.14
Paraplegic	.49	.09

Table 49

Summary of Analysis of Variance of Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.050	.025	3.97
Within	46	.291	.006	
Total	48	.341		

Means and Standard Deviations

Group	Mean	S.D.
Control	.44	.08
Cardiac	.38	.06
Paraplegic	.48	.08

The picture for respiration cycle time is rounded off when we examine these ratios during the pursuit rotor trials adjusted for each individual for variations in pre-stimulus values. The pattern previously observed continues with the paraplegic group still exhibiting consistently the highest ratios and the cardiac group falling either intermediate or on the low end (Tables 50–53).

Table 50

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Accurate Trials, Day 1

Souce of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.078	.039	3.40
Within	52	.591	.011	
Total	54	.669		

Means and Standard Deviations

Group	Mean	S.D.
Control	.36	.10
Cardiac	.41	.13
Paraplegic	.45	.11

Table 51

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.133	.067	5.80
Within	52	.598	.011	
Total	54	.731		

Means and Standard Deviations

Group	Mean	S.D.
Control	.40	.09
Cardiac	.33	.13
Paraplegic	.48	.12

Table 52

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 1

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.100	.050	7.2
Within	53	.369	.007	
Total	55	.469		

Means and Standard Deviations

Group	Mean	S.D.
Control	.37	.07
Cardiac	.40	.14
Paraplegic	.47	.09

Table 53

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Time Ratio: Inaccurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.140	.070	5.82
Within	52	.623	.012	
Total	54	.763		

Means and Standard Deviations

Group	Mean	S.D.
Control	.41	.11
Cardiac	.32	.10
Paraplegic	.48	.12

Although the picture for respiration volume is similar to that observed for cycle time, the measure appears to be less reliable (consistent with the results of the test-retest reliability analyses) and fewer effects achieve significance. The inspiration volume to the total cycle volume to the accurate trials on day 2 is one that does, and typifies the pattern obtained for respiratory volume (Table 54).

Again we see the effect as primarily due to the consistent behavior of the paraplegic group which evidences the highest volumes. Although again the behavior of the cardiac group appears less remarkable as it is not consistent over days like the paraplegic group.

Table 54

Summary of Analysis of Variance of Stimulus Inspiration Volume Ratio: Accurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.103	.051	3.83
Within	46	.617	.013	
Total	48	.720		

Means and Standard Deviations

Group	Mean	S.D.
Control	.48	.09
Cardiac	.38	.15
Paraplegic	.53	.14

When the respiration volume ratios are corrected for differences that existed on the pre-stimulus level, the adjusted inaccurate trials on day 2 also evidence a significant differentiation among the groups in the previously described pattern (Table 55).

Table 55

Summary of Analysis of Variance of Adjusted Stimulus Inspiration Volume Ratio: Inaccurate Trials, Day 2

Source of Variation	D.F.	Sum of Squares	Mean Square	F
Between	2	.104	.052	3.93
Within	51	.679	.013	
Total	53	.783		

Means and Standard Deviations

Group	Mean	S.D.
Control	.48	.11
Cardiac	.38	.10
Paraplegic	.52	.14

Discussion – Group Differences

The results of the analysis of the group differences support in general the major hypothesis of the present study, i.e., that of preferred channels of physiological response in the different groups of disabled subjects related to the nature of their disability. They also support the general research strategy of sampling a variety of situations in which the behavior of the several disabled groups was studied. Different patterns of physiological response were obtained in the different experimental situations and the ways they were interpreted by the different groups of disabled subjects, or to more extrinsic properties of the experimental situations such as their ability to allow for reliable measurement of the physiological response channels.

The most interesting results of the study were produced during the performance of the emotion provoking pictures test, a procedure during which the subject sits passively and attends to either emotionally arousing or netural slides. On this test, both heart rate and respiration measures gave rise to significant differences among the groups. The cardiac group exhibited a significant tendency to differentiate between the high and low effect stimuli with their cardiovascular responses. This was the only instance of such physiological differentiation between the stimulus or performance levels within an experimental condition. This phenomenon was evident in all aspects of cardiovascular activity measured, average heart rate, and minimum and maximum heart rate. Thus it would appear that the cardiac group is particularly sensitive to affective or emotionally arousing situations and that they tend to exhibit their differential sensitivity primarily in cardiovascular response.

On the other hand, the paraplegic group was more likely to exhibit their differential physiological responses in their respiratory behavior. Their idiosyncratic respiratory functioning occurred throughout the experimental procedures and was apparent in the response to all three tests, the vocabulary, the pictures, and the pursuit rotor test.

In each case, the paraplegics' respiratory pattern tended to differ from the normal controls and from the cardiac groups in that they spend a disporportionately large amount of time in the inspiration phase of the respiratory cycle. On the other hand, this phenomenon tends to be more indiscriminate in that it occurs in practically all aspects of each of the experimental tasks but does not exhibit any sensitivity to variations within the tasks, e.g. right or wrong vocabulary items, emotional or neutral stimuli, etc.

The results of the evaluation of the reliability of the cardiovascular and respiratory measures would lead us, however, to mitigate our certainty concerning some of the above generalizations. Since high reliabilities were only obtained for the cardiovascular measures on the emotion provoking pictures test, we cannot be sure that the cardiac group would not have evidenced differential cardiovascular response on the other two procedures had they been able to produce more reliable cardiovascular responding and/or measurement. On the other hand, the lack of significant effects with respect to respiratory measures in the cardiac group cannot be attributed to analogous differences in reliability for the respiratory measures exhibited consistently high reliabilities on all the experimental tasks.

On the pursuit rotor task, with respect to their cardiovascular responses, the two disabled groups performed in similar fashion and differed from the control group subjects. Increased levels and variability of heart rates were found in the control group with improved performance on the pursuit rotor task. This is possibly related to the mechanism recently described by Lacey in which heart rate acceleration is associated with environmental rejection and deceleration with environmental intake. The control subjects would then be seen as mobilizing their cardiovascular mechanisms to reject distracting environmental stimuli, thus giving rise to more accurate performance on the pursuit rotor task. The two disabled groups did not or could not make use of such a mechanism.

Individual Differences

The third series of analyses was directed at determining the relationships between certain selected assessment variables, test anxiety, attitudes towards disabled, and need achievement, to the behavioral and physiological measures obtained during the performance of the several experimental tasks. Here, as in the determination of the reliabilities, it would have been optimal to obtain these correlations separately for each of the three groups of subjects and thus be able to compare the correlations between the variables for the different subject groups. But again, the presence of small and variable group sizes made such an analysis infeasible and all the subjects were pooled in the analyses presented below.

Vocabulary Test

Each of the assessment variables was correlated to the measures obtained as output from the series 2 programs of Human Resources Center. As in the analysis of the reliability of the dependent measures, not all measures were available for all subjects, and a missing data correlation routine was used to maximize the sample size for any particular comparison. The sample sizes were all large and ranged from 66 to 88 with correlations significant at the .05 level of significance ranging from .24 to .21.

The significant correlates of Test Anxiety are given in Table 56.

High test anxiety was correlated with higher mean levels of heart rate and lower minimum levels of heart rate. It was also associated positively with greater respiratory cycle volume differentiation between correct and incorrect items and confident and non-confident. Individuals higher on test anxiety were more likely to differentiate in cycle volume between vocabulary items which were either correct or incorrect or about which they were either confident or not confident. This is the only instance thus far in which respiratory response has been significantly associated with such differentiation.

Table 56

Vocabulary: Correlates of TAQ

Measures		Day	Correlates
Adjusted Mean Heart Rates:	Incorrect	2	+.27
Minimum Heart Rates:	Right	2	–.26
Minimum Heart Rates:	Wrong	1	–.24
Minimum Heart Rates:	Wrong	2	–.33
Minimum Heart Rates:	Confident	2	–.35
Minimum Heart Rates:	Non-Confident	1	–.22

The correlates of need achievement are given in Table 57.

Subjects scoring high on need achievement were more likely to express greater confidence in their vocabulary test performance. This was not however related to the number of items they were actually correct on. High need achievement was also inversely related to the degree of cardiovascular differentiation between vocabulary items. Low need achievement scorers were more likely to differentiate between right and wrong and confident and non-confident vocabulary items in their maximum heart rates and in the difference between their maximum and minimum heart rates. Only one correlate of respiratory function was found.

Table 57

Vocabulary: Correlates of Need Achievement

Measures		Day	Correlates
# Confident		2	+.23
Maximum-Minimum Heart Rates:	Non-Confident	2	+.26
Adjusted Inspiration Cycle Time:	Non-Confident	2	–.23

Numerous correlates of scores on the attitudes toward disabled test were found. They are given in Table 58.

Subjects who had more positive attitudes towards disabled were more likely to have greater numbers of vocabulary items about which they were confident, right and confident and a higher coefficient of concordance between the two. All aspects of cardiovascular activity were also likely to be directly related to ATDP scores including heart rate, pre-stimulus levels, stimulus mean levels, maximal and minimal levels to correct, incorrect, confident and non-confident items. No significant correlates were found for any aspect of respiratory activity.

Table 58

Vocabulary: Correlates of ATDP

Measures		Day	Correlates
# Confident		2	+.38
Right + Confident		2	+.36
Coefficient		2	+.25
Pre-Stimulus Heart Rate:	Correct	1	+.25
Pre-Stimulus Heart Rate:	Incorrect	1	+.32
Pre-Stimulus Heart Rate:	Confident	1	+.26
Pre-Stimulus Heart Rate:	Non-Confident	1	+.26
Mean Heart Rate:	Incorrect	1	+.26
Mean Heart Rate:	Confident	1	+.22
Mean Heart Rate:	Non-Confident	1	+.23
Adjusted Mean Heart Rate:	Correct	1	+.26
Adjusted Mean Heart Rate:	Incorrect	1	+.28
Adjusted Mean Heart Rate:	Confident	1	+.26
Adjusted Mean Heart Rate:	Non-Confident	1	+.24
Adjusted Maximum Heart Rates:	Correct	1	+.27
Adjusted Maximum Heart Rates:	Incorrect	1	+.27
Minimum Heart Rates	Correct	2	+.26

Measures		Day	Correlates
Minimum Heart Rates:	Incorrect	2	+.37
Minimum Heart Rates:	Confident	2	+.39
Minimum Heart Rates:	Non-Confident	2	+.26
Adjusted Minimum Heart Rates:	Correct	1	+.27
Adjusted Minimum Heart Rates:	Incorrect	1	+.30
Adjusted Minimum Heart Rates:	Confident	1	+.26
Adjusted Minimum Heart Rates:	Non-Confident	1	+.25
Maximum-Minimum Heart Rates:	Non-Confident	1	+.25
Adjusted Maximum-Minimum Heart Rate:	Non-Confident	1	+.25
Adjusted Maximum-Minimum Heart Rate:	Correct	1	+.27
Adjusted Maximum-Minimum Heart Rate:	Incorrect	1	+.27
Adjusted Maximum-Minimum Heart Rate:	Confident	1	+.27
Adjusted Maximum-Minimum Heart Rate:	Non-Confident	1	+.26

Emotion Provoking Pictures Test

The most "psychological" of the procedures, the emotion provoking pictures test, yielded the fewest correlates of our assessment variables. No significant correlates of need achievement were found to any of the measures taken during the pictures task, while test anxiety produced only 2 significant correlations. High test anxiety was associated with lower minimum heart rates on day 2 to both emotional and neutral stimuli.

The most numerous correlations were again produced by the attitudes toward disability test, these all occurring to Day 1 measures and mainly to aspects of cardiovascular functioning. The correlations are summarized in Table 59.

Subjects with more positive attitudes towards disability were more likely to exhibit higher pre-stimulus, stimulus and maximal heart rates during the presentation of the pictorial stimuli. They were also more likely to evidence differentiation between the emotional and neutral stimuli in their minimum heart rates and respiration cycle volumes.

Table 59

Pictures: Correlates of ATDP

Measures		Day	Correlates
Pre-Stimulus Mean Heart Rate:	Emotion	1	+.25
Mean Heart Rate:	Emotion	1	+.27
Mean Heart Rate:	Neutral	1	+.27
Maximum Heart Rate:	Emotion	1	+.24
Maximum Heart Rate:	Neutral	1	+.25

Pursuit Rotor

All three of the assessment variables gave rise to some correlates of performance on the pursuit rotor task. The correlates of test anxiety are given in Table 60.

On accurate trials, subjects high in test anxiety were more likely to have lower heart rates on both day 1 and day 2. They were also less likely to evidence differentiation between accurate and inaccurate trials in their maximum heart rates and heart rate ranges on day 2.

Table 60

Pursuit Rotor: Correlates of TAQ

Measures		Day	Correlates
Mean Heart Rate:	Accurate	1	–.24
Mean Heart Rate:	Accurate	2	–.24
Pre-Stimulus Inspiration Cycle Volume:	Inaccurate	1	+.23

Several aspects of cardiovascular activity on the pursuit rotor task were related to need achievement scores of the subjects. The significant eorrelations are given in Table 61.

On both accurate and inaccurate trials of day 2 high need achievement scores were related to high pre-stimulus heart rates, and adjusted stimulus mean and maximum heart rates. While high need achievement scores were negatively related to minimum heart rates on both accurate and inaccurate trials, when the minimum heart rates were adjusted for pre-stimulus levels, the correlations became positive. There were also positive correlations between need achievement and heart range when adjusted for pre-stimulus levels.

Table 61

Pursuit Rotor: Correlates of Need Achievement

Measures		Day	Correlates
Pre-Stimulus Heart Rate:	Inaccurate	2	+.33
Adjusted Mean Heart Rate:	Accurate	2	+.25
Adjusted Mean Heart Rate:	Inaccurate	2	+.31
Adjusted Maximum Heart Rate:	Accurate	2	+.26
Adjusted Maximum Heart Rate:	Inaccurate	2	+.29
Minimum Heart Rate:	Accurate	2	-.27
Minimum Heart Rate:	Inaccurate	2	-.24
Adjusted Minimum Heart Rate:	Accurate	2	+.27
Adjusted Minimum Heart Rate:	Inaccurate	2	+.31
Adjusted Maximum-Minimum Heart Rate:	Accurate	2	+.26
Adjusted Maximum-Minimum Heart Rate:	Inaccurate	2	+.29

Again, the most numerous correlations were found with respect to the ATDP scores and are summarized in Table 62.

More positive attitudes towards disability are associated on day 2 with all aspects of cardiovascular activity during the pursuit rotor task. Higher pre-stimulus heart rates to both accurate and inaccurate trials, adjusted mean heart rates, maximum and adjusted maximum heart rates, adjusted minimum and heart rate ranges are all associated with higher scores on the ATDP. Moreover, high scorers were also less likely to evidence differentiation between accurate and inaccurate trials in their mean heart rates, maximum heart rates, and heart rate ranges. Inspiration cycle time and volume ratios on day 1 were also negatively related to ATDP scores on day 1, while in inspiration cycle time, high scorers were more likely to differentiate between accurate and inaccurate trials.

Table 62

Pursuit Rotor: Correlates of ATDP

Measures		Day	Correlates
Pre-Stimulus Heart Rate:	Accurate	2	+.35
Pre-Stimulus Heart Rate:	Inaccurate	2	+.29
Adjusted Mean Heart Rate:	Accurate	2	+.37
Adjusted Mean Heart Rate:	Inaccurate	2	+.27
Maximum Heart Rate:	Accurate	2	+.23
Adjusted Maximum Heart Rate:	Inaccurate	2	+.36
Adjusted Minimum Heart Rate:	Accurate	1	+.22
Adjusted Minimum Heart Rate:	Accurate	2	+.34
Adjusted Minimum Heart Rate:	Inaccurate	2	+.29
Maximum-Minimum Heart Rate:	Accurate	2	+.23
Adjusted Maximum-Minimum Heart Rate:	Inaccurate	2	+.36
Inspiration Cycle Time:	Inaccurate	1	–.25
Inspiration Cycle Volume:	Inaccurate	1	–.29

Discussion – Individual Differences

The analysis of the individual difference correlates revealed two unexpected results. First, the emotion provoking pictures test, in many ways the most "psychological" of the test procedures, yielded the least individual difference correlates. Only the Attitudes Towards Disabled Persons test produced a reasonable number of correlates of this test, Need Achievement none at all, and Test Anxiety only two.

Second, looking at the results from the point of view of independent variables, rather than the experimental test procedures we find that the Attitudes Towards Disabled Persons test yielded consistently the largest numbers of significant correlates, with Test Anxiety and Need Achievement following with a similar number of correlates.

SUMMARY

This study attempted to look at cardiac and respiratory functioning from several points of view. First, it attempted to view these variables using a psychometric model, specifically to observe the extent to which the measures of these responses were reliable. Second, to see the extent to which the responses varied as a function of the psychological stimulus situation presented to the subject. Third, to see whether or not heart and respiratory functions, respectively, were different among groups of people whose disabilities involved cardiac and respiratory difficulties. Finally, to see whether or not any of these physiological measures were related to selected demographic and personality characteristics.

Specifically, a group of 85 subjects participated in the study: 24 paraplegics, 10 cardiacs and 51 physically normal control subjects. All were employees of Human Resources Center in Albertson, Long Island.

The equipment used to measure physiological responses was a miniaturized telemetering system developed at the Center. The electrocardiogram recordings were taken from lead V 4 and the respiration measures were taken using a face mask which measures inspiratory and expiratory rate and volume. Neither of these devices caused any discomfort to the subject or interfered with his behavior in responding to the stimulus conditions.

The three tasks were developed to represent three different kinds of low level psychological stress. The first was a series of pictures, half of which were assumed to provoke emotion, while the other half were presumed to be neutral. All pictures were of physically disabled persons. Half of the photographs were rated as likely to be distressing in terms of the relatively non-aesthetic appearance of the disability. These pictures were prepared on 35 mm. slides and projected at a distance of about six feet from the subject. He was simply to look at the pictures and make no overt responses. This task was considered to be a relatively pure psychological emotional task both non-intellectual and non-motoric in nature. The second task involved responses by the subject to a series of vocabulary test items similarly presented with the stimulus words and alternatives on 35 mm. slides. The subject's task was to choose the correct alternative from five suggested definitions for the word in question. In addition, he was asked to indicate whether or not he was "confident" about his answer. This task was assumed to be more intellectual than the first and less pure in its emotional quality. The third task involved tracking a moving target with a stylus using a pursuit rotor device. By attending to a visual signal the subject knew when he was on and off target. Two different speeds of rotation of the target were used. This was assumed to be a non-intellectual task which would generate low levels of stress through motor behavior.

Each subject was also given a battery of psychometric devices including a Scale to Measure Attitudes Toward Disabled Persons, an Adjective Check List (scored for the need for achievement measure), a Test Anxiety Questionnaire, and a form inquiring into his medical history. Subjects were tested using the dynamic tasks on two occasions separated by a period of one week. The Test Anxiety Questionnaire and Adjective Check List were given at the beginning of the first session. The Attitudes Toward Disabled Persons Scale and medical form were administered during the second session.

Perhaps the most unusual feature of the study was its attempt to view physiological measures in a psychometric model. That is, to look at the reliability and other correlates of respiration and heart function. First, viewing the results in terms of test-retest reliability, one could say that these physiological phenomena have relatively low reliability in comparison with the usual psychometric standards. Generally speaking, the highest reliabilities

ranged between .6 and .7 but such values were by far the exception rather than the rule. In many cases the test-retest reliability correlations were not significantly different from zero at the five percent level when values of approximately .25 were necessary to reach significance. The reliability data did suggest that respiration measures were substantially more reliable than heart measures. Further, when one varies the task condition, the more dynamic the subject's response the lower the reliability of the physiological measure over the one week interval. Thus, the reliability coefficients were generally higher when the subject was asked to simply view the emotion provoking pictures and sat quietly while the pictures were being presented. When he was asked to interact in some form with the experimental situation (specifically to select the correct answer on the vocabulary tests and indicate his level of confidence, or to track the moving target with a stylus in the pursuit rotor task) the reliability coefficients were lower.

When any measure has limited reliability further analysis of the data is difficult. Where the phenomenon under investigation does not have a reliability coefficient significantly different from zero, the failure to find significant relationships under other situations may simply be due to the fact that the phenonema to be studied cannot be measured in the same way on two separate occasions. Where moderate reliabilities obtained, further study was possible.

The data with regard to the type of physical disability and differential cardiac or respiratory response proved to be interesting. The responses of the cardiac patients were significantly different from either the paraplegics or physically normal control groups in those conditions where cardiac response was reliable (i.e., the emotion provoking pictures). On the other hand the paraplegics with limited muscle control responded differently in their respiratory rates from either the cardiac or physically normals under a variety of conditions. Thus, it would appear that one's physical disability is reflected in the form in which he reacts to low levels of psychological stress at least when physiological measures achieve a reasonable degree of reliability under task conditions.

Finally, attempts to correlate physiological responses with psychometric test scores revealed a bewildering array of correlations which suggested no clear or meaningful pattern to the investigators. Once again, this may have been due to the fact that the physiological measures had very low reliability coefficients. Further, the psychometric measures used were largely personality and attitude scales which tend to have relatively low psychometric reliabilities when compared with achievement or aptitude tests. Thus, when one attempts to correlate two relatively unreliable instruments the resulting correlations will be low. Where significant correlations were obtained they were typically between .25 and .30, but an analysis of their patterns failed to reveal anything meaningful.

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APPENDIX A

Code Number ______________

GENERAL INFORMATION SHEET

NOT TO BE FILLED IN BY SUBJECT

Subject ID Number				
Age (in Months)				
Sex				
Date Recorded				
Tape Recorded on				
Recording Number on Tape				

Name ______________________________ Date ______________

Sex: Female __________ Male __________ Age: (years) __________ (months) ______

Mailing Address ____

____

Telephone Number ______________________________

Education: Circle the highest grade completed.

Elementary School	High School	College
5 6 7 8	1 2 3 4	1 2 3 4

What was your major field (if any)? ______________________________

What was your minor field (if any)? ______________________________

How is your general health at the present time?

Excellent __________ Good __________ Fair __________ Poor __________

Code Number ____________

MEDICAL HISTORY

I. Family History

	Living		Deceased	
	Age	Health	Age at Death	Cause
Father				
Mother				
Sisters				
Brothers				

II. Personal History

Place a check before any of the following diseases you have had.
Following the name, write the age or ages at which you had the disease.

____	Arthritis	____	____	Kidney Disease	____
____	Asthma	____	____	German Measles	____
____	Bronchitis	____	____	Migraine	____
____	Cancer	____	____	Nervous Breakdown	____
____	Convulsions	____	____	Pleurisy	____
____	Diabetes	____	____	Pneumonia	____
____	Epilepsy	____	____	Polio	____
____	Goiter	____	____	Rheumatic Fever	____
____	Heart Disease	____	____	Tonsillitis	____
____	High Blood Pressure	____	____	Whooping Cough	____
____	Hepatitis	____	____	Tuberculosis	____

Code Number _______________

Have you had any of the following symptoms repeatedly? Check "yes" or "no" for each symptom.

YES	NO	
_____	_____	1. Trouble with eyes or ears. Vision corrected with glasses? Yes _____ No _____
_____	_____	2. Frequent severe headaches.
_____	_____	3. Spontaneous nosebleeds.
_____	_____	4. Persistent cough.
_____	_____	5. Blood spitting.
_____	_____	6. Shortness of breath.
_____	_____	7. Asthma.
_____	_____	8. Pain in the chest.
_____	_____	9. Irregular heartbeat.
_____	_____	10. Swelling of feet.
_____	_____	11. High Blood pressure.
_____	_____	12. Frequent nausea or vomiting.
_____	_____	13. Frequent diarrhea.
_____	_____	14. Blood in vomitus.
_____	_____	15. Pain in abdomen.
_____	_____	16. Allergy to drugs, foods, or pollens.
_____	_____	17. Burning or pain on urination.
_____	_____	18. Blood or pus in urine.
_____	_____	19. Periods of convulsions, unconsciousness, or paralysis.
_____	_____	20. Backache or joint trouble.
_____	_____	21. Do you get up at night to urinate?
_____	_____	22. Do you take insulin or thyroid?
_____	_____	23. Do you take any medication regularly? If so, what? _______________
_____	_____	24. Have you had counseling for mental health?
_____	_____	25. Do you have thin blood (anemia)?

Code Number ____________

Have you had any hospitalization, broken bones*, or surgical operations?
Please list:

DATE	HOSPITAL	REASONS

* For broken bones, list which.

Are you a smoker? Yes ______ No ______

Approximately how much do you smoke per day?

Less than 1 pack ______

Between 1 and 2 packs ______

Over 2 packs ______

Pipe ______

Cigar ______

78

APPENDIX B

Means, Standard Deviations and Number of Observations for the Vocabulary Test Stimulus Conditions

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
# Correct		16.5	4.1	83	16.5	4.2	70
# Confident		14.9	6.3	83	13.5	6.3	70
# Correct and Confident		12.1	5.4	83	10.9	5.2	70
Pre-Stimulus Heart Rates:	Correct Item	83.5	19.4	80	84.8	17.7	70
Pre-Stimulus Heart Rates:	Incorrect Item	83.2	19.4	80	84.6	17.2	70
Pre-Stimulus Heart Rates:	Confident Item	84.3	20.5	76	85.4	17.9	66
Pre-Stimulus Heart Rates:	Not Confident Item	84.0	19.2	76	84.8	17.7	66
Mean Heart Rate:	Correct Item	81.4	18.4	81	85.4	21.7	69
Mean Heart Rate:	Incorrect Item	82.1	19.6	81	83.5	18.9	69
Mean Heart Rate:	Confident Item	80.7	23.8	79	85.6	22.1	65
Mean Heart Rate:	Not Confident Item	81.3	18.3	81	84.7	20.5	68
Adjusted Mean Heart Rate:	Correct Item	83.7	19.5	79	82.6	23.5	68
Adjusted Mean Heart Rate:	Incorrect Item	83.6	19.1	79	81.7	21.7	67
Adjusted Mean Heart Rate:	Confident Item	84.9	19.9	72	84.1	21.2	63
Adjusted Mean Heart Rate:	Not Confident Item	85.0	19.5	72	83.5	20.3	63
Maximum Heart Rate:	Correct Item	112.7	38.8	81	119.0	42.8	68
Maximum Heart Rate:	Incorrect Item	111.4	41.2	81	117.7	45.6	69
Maximum Heart Rate:	Confident Item	114.6	47.2	79	118.4	43.8	64
Maximum Heart Rate:	Not Confident Item	114.0	40.7	81	118.4	45.6	68
Adjusted Maximum Heart Rate:	Correct Item	83.1	19.2	79	84.8	18.1	68
Adjusted Maximum Heart Rate:	Incorrect Item	83.4	19.6	79	84.4	17.4	68

Vocabulary Stimulus Conditions (Continued)

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
Adjusted Maximum Heart Rate:	Confident Item	83.6	22.3	74	85.5	18.2	66
Adjusted Maximum Heart Rate:	Not Confident Item	83.1	21.7	74	84.8	17.4	66
Minimum Heart Rates:	Correct Item	67.6	11.3	81	70.4	15.5	69
Minimum Heart Rates:	Incorrect Item	68.0	11.7	81	68.9	9.4	69
Minimum Heart Rates:	Confident Item	66.1	15.6	79	68.8	9.8	65
Minimum Heart Rates:	Not Confident Item	68.0	11.8	81	70.7	17.6	69
Adjusted Minimum Heart Rates:	Correct Item	83.5	19.5	79	85.6	20.8	69
Adjusted Minimum Heart Rates:	Incorrect Item	83.6	19.5	79	85.0	18.3	69
Adjusted Minimum Heart Rates:	Confident Item	83.3	22.9	74	86.2	20.5	65
Adjusted Minimum Heart Rates:	Not Confident Item	82.7	21.5	74	85.7	18.7	65
Heart Rate Changes (Max.-Min.)	Correct Item	48.0	38.9	81	52.6	45.3	69
Heart Rate Changes (Max.-Min.)	Incorrect Item	47.5	42.5	81	52.6	49.9	69
Heart Rate Changes (Max.-Min.)	Confident Item	48.6	42.3	79	58.8	55.7	65
Heart Rate Changes (Max.-Min.)	Not Confident Item	46.5	39.5	81	54.6	51.7	69
Adjusted Heart Rate Changes (Max.-Min.)	Correct Item	83.4	19.4	80	84.7	17.7	70
Adjusted Heart Rate Changes (Max.-Min.)	Incorrect Item	83.5	19.2	80	84.5	17.0	70
Adjusted Heart Rate Changes (Max.-Min.)	Confident Item	84.4	19.9	74	85.1	17.9	65

Vocabulary Stimulus Conditions (Continued)

Variables		Day I M	S.D.	N	Day II M	S.D.	N
Adjusted Heart Rate Changes (Max.-Min.)	Not Confident Item	84.3	19.7	74	84.8	17.3	66
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Correct Item	.383	.11	80	.401	.10	69
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.384	.11	80	.393	.11	70
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.379	.11	75	.409	.10	66
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.380	.11	76	.402	.10	66
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.421	.13	80	.460	.11	68
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.413	.13	80	.440	.13	70
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.415	.13	74	.459	.12	66
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Not Confident Item	.409	.13	77	.456	.12	66
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Correct Item	.425	.09	81	.420	.10	69
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.426	.09	81	.426	.10	69
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.425	.09	77	.434	.10	65

Vocabulary Stimulus Conditions (Continued)

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.427	.09	81	.423	.10	69
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Correct Item	.384	.11	79	.398	.11	69
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Incorrect Item	.380	.11	79	.398	.10	69
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Confident Item	.383	.11	74	.406	.10	65
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Not Confident Item	.381	.11	74	.405	.10	65
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.478	.12	81	.472	.13	69
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.481	.11	81	.478	.13	69
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.469	.13	77	.485	.12	65
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Not Confident Item	.479	.11	81	.473	.13	69
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Correct Item	.417	.13	80	.453	.12	70
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Incorrect Item	.414	.13	80	.438	.13	70
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Confident Item	.418	.13	74	.461	.12	65
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Not Confident Item	.410	.13	75	.457	.12	65

Means, Standard Deviations and Number of Observations for the Emotion Provoking Pictures Test Stimulus Conditions

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
Pre-Stimulus Mean Heart Rate:	Emotional Stimuli	80.0	17.4	81	78.6	9.2	71
Pre-Stimulus Mean Heart Rate:	Neutral Stimuli	80.3	18.5	81	79.1	9.0	71
Stimulus Mean Heart Rate:	Emotional Stimuli	78.1	16.7	83	77.8	8.6	70
Stimulus Mean Heart Rate:	Neutral Stimuli	78.9	17.3	83	78.3	9.1	70
Adjusted Stimulus Mean Heart Rate:	Emotional Stimuli	80.0	17.7	78	77.5	13.0	70
Adjusted Stimulus Mean Heart Rate:	Neutral Stimuli	79.7	17.8	78	77.8	13.0	70
Maximum Heart Rate:	Emotional Stimuli	101.1	35.0	83	97.9	19.2	70
Maximum Heart Rate:	Neutral Stimuli	101.3	36.8	83	98.2	20.0	70
Adjusted Maximum Heart Rate:	Emotional Stimuli	79.8	36.8	81	78.6	20.0	70
Adjusted Maximum Heart Rate:	Neutral Stimuli	80.0	17.4	81	79.0	8.9	70
Minimum Heart Rate:	Emotional Stimuli	68.4	12.4	83	69.2	9.3	70
Minimum Heart Rate:	Neutral Stimuli	69.1	12.7	83	69.8	8.4	70
Adjusted Minimum Heart Rate:	Emotional Stimuli	79.9	18.0	77	78.4	8.8	70
Adjusted Minimum Heart Rate:	Neutral Stimuli	80.1	17.7	78	78.8	8.8	70
Heart Rate Changes (Max.-Min.)	Emotional Stimuli	33.5	33.4	83	30.9	20.8	70
Heart Rate Changes (Max.-Min.)	Neutral Stimuli	31.8	34.2	83	31.4	22.5	70
Adjusted Heart Rate Changes (Max.-Min.)	Emotional Stimuli	78.1	20.9	80	87.5	73.8	71
Adjusted Heart Rate Changes (Max.-Min.)	Neutral Stimuli	79.4	20.0	80	79.2	9.0	70

Emotion Provoking Pictures Stimulus Conditions (Continued)

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Emotional Stimuli	.384	.12	80	.412	.12	70
Respiration: Pre-Stimulus Inspiration Time/Total Cycle Time:	Neutral Stimuli	.380	.12	79	.404	.14	70
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Emotional Stimuli	.419	.14	80	.462	.15	70
Respiration: Pre-Stimulus Inspiration Volume/Total Cycle Volume:	Neutral Stimuli	.428	.14	79	.457	.16	70
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Emotional Stimuli	.443	.09	83	.451	.10	70
Respiration: Stimulus Inspiration Time/Total Cycle Time:	Neutral Stimuli	.439	.09	83	.451	.10	70
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Emotional Stimuli	.392	.14	80	.413	.13	70
Respiration: Adjusted Stimulus Inspiration Time/Total Cycle Time:	Neutral Stimuli	.384	.12	79	.403	.13	69
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Emotional Stimuli	.491	.11	83	.511	.14	70
Respiration: Stimulus Inspiration Volume/Total Cycle Volume:	Neutral Stimuli	.489	.11	83	.511	.13	70
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Emotional Stimuli	.416	.14	80	.568	.91	70
Respiration: Adjusted Stimulus Inspiration Volume/Total Cycle Volume:	Neutral Stimuli	.434	.15	79	.562	.91	70

Means, Standard Deviations and Number of Observations
for the Pursuit Rotor Test Stimulus Conditions

Variables		Day I M	Day I S.D.	Day I N	Day II M	Day II S.D.	Day II N
Pre-trial Mean Heart Rate:	Accurate	89.6	23.8	58	89.3	15.3	58
Pre-trial Mean Heart Rate:	Inaccurate	90.9	24.9	58	91.2	28.8	57
Trial Mean Heart Rate:	Accurate	88.8	21.0	56	94.1	25.1	52
Trial Mean Heart Rate:	Inaccurate	92.1	22.2	56	96.7	19.5	52
Adjusted Trial Mean Heart Rate:	Accurate	90.8	23.8	58	89.6	15.0	58
Adjusted Trial Mean Heart Rate:	Inaccurate	89.9	23.6	58	91.1	27.0	58
Trial Maximum Heart Rate:	Accurate	149.1	55.0	56	159.7	62.2	52
Trial Maximum Heart Rate:	Inaccurate	171.7	57.3	56	164.8	64.1	52
Adjusted Trial Maximum Heart Rate:	Accurate	101.8	82.8	58	90.5	16.5	58
Adjusted Trial Maximum Heart Rate:	Inaccurate	90.8	26.5	58	90.4	27.3	58
Trial Minimum Heart Rate:	Accurate	70.2	14.4	56	68.9	13.8	52
Trial Minimum Heart Rate:	Inaccurate	71.0	13.5	56	69.2	14.4	52
Adjusted Trial Minimum Heart Rate:	Accurate	91.7	23.5	56	90.2	16.4	58
Adjusted Trial Minimum Heart Rate:	Inaccurate	89.3	22.7	56	91.0	27.1	58
Heart Rate Change (Max.-Min.)	Accurate	80.3	56.4	56	91.8	62.7	52
Heart Rate Change (Max.-Min.)	Inaccurate	103.6	59.6	56	99.8	62.0	52
Adjusted Heart Rate Change (Max.-Min.)	Accurate	89.4	25.2	55	90.4	17.3	57
Adjusted Heart Rate Change (Max.-Min.)	Inaccurate	89.4	24.1	55	90.3	26.9	57

Pursuit Rotor Stimulus Conditions (Continued)

Variables		Day I M	S.D.	N	Day II M	S.D.	N
Respiration: Pre-Trial Inspiration Time/Total Cycle Time:	Accurate	.390	.11	57	.417	.12	58
Respiration: Pre-Trial Inspiration Time/Total Cycle Time:	Inaccurate	.400	.09	58	.418	.11	58
Respiration: Pre-Trial Inspiration Volume/Total Cycle Volume:	Accurate	.427	.12	58	.489	.14	57
Respiration: Pre-Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.435	.12	58	.479	.14	57
Respiration: Trial Inspiration Time/Total Cycle Time:	Accurate	.429	.08	56	.442	.09	51
Respiration: Trial Inspiration Time/Total Cycle Time:	Inaccurate	.434	.08	56	.442	.08	51
Respiration: Adjusted Trial Inspiration Time/Total Cycle Time:	Accurate	.391	.11	57	.414	.11	57
Respiration: Adjusted Trial Inspiration Time/Total Cycle Time:	Inaccurate	.400	.09	58	.415	.12	57
Respiration: Trial Inspiration Volume/Total Cycle Volume:	Accurate	.447	.12	56	.474	.12	51
Respiration: Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.451	.11	56	.471	.10	51
Respiration: Adjusted Trial Inspiration Volume/Total Cycle Volume:	Accurate	.427	.12	58	.465	.12	56
Respiration: Adjusted Trial Inspiration Volume/Total Cycle Volume:	Inaccurate	.437	.11	58	.479	.12	56