WADC TECHNICAL REPORT 59-505

PROJECT MERCURY CANDIDATE EVALUATION PROGRAM

Charles L. Wilson, Captain, USAF, MC
Editor

Aerospace Medical Laboratory

DECEMBER 1959

WRIGHT AIR DEVELOPMENT CENTER

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

- - - - -

Qualified requesters may obtain copies of this report from the Armed Services Technical Information Agency, (ASTIA), Arlington Hall Station, Arlington 12, Virginia.

- - - - -

Copies of WADC Technical Reports and Technical Notes should not be returned to the Wright Air Development Center unless return is required by security considerations, contractual obligations, or notice on a specific document.

WADC TECHNICAL REPORT 59-505

PROJECT MERCURY CANDIDATE EVALUATION PROGRAM

Charles L. Wilson, Captain, USAF, MC
Editor

Aerospace Medical Laboratory

DECEMBER 1959

Project No. 7164
Task No. 71832

WRIGHT AIR DEVELOPMENT CENTER
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

800 – March 1960 – 31-913

FOREWORD

This investigation was directed by Brig. Gen. Don Flickinger, USAF, MC, Command Surgeon, Air Research and Development Command. The testing, begun on 16 February 1959 and completed on 27 March 1959, was performed under Project No. 7164, "Physiology of Flight," Task No. 71332, "Physiological Criteria for Extended Environments." Col. J. P. Stapp, USAF, MC, Chief, Aerospace Medical Laboratory,* Wright Air Development Center, appointed the necessary staff to effect this investigation. The testing was conducted at the Aerospace Medical Laboratory of the Wright Air Development Center.

This project required the joint participation of many different professional groups before, during, and after the actual testing. Each individual in his selfless and energetic manner contributed significantly toward this undertaking.

The Aerospace Medical Laboratory staff experienced a warm association with all of the candidates. Despite the physical and mental fatigue engendered by the program, the candidates demonstrated inspiring competition and unfaltering equanimity. The staff wishes to express its deepest gratitude to them for their outstanding cooperation and understanding.

Special thanks go to the following personnel of the Aerospace Medical Laboratory: Capt. Edmund B. Weis, Jr., USAF, MC, who critically reviewed this entire manuscript; Miss Beverly A. Bruns, who prepared weekly reports and handled the immense amount of correspondence during and after the testing program; and Mrs. Heather R. Braman, who was responsible for the editing, typing, and layout of this entire report.

* The Aero Medical Laboratory was redesignated Aerospace Medical Laboratory on 1 August 1959.

ABSTRACT

A battery of physiological, psychological, and biochemical tests was performed by the Aerospace Medical Laboratory on the candidates for the National Aeronautics and Space Administration's Project Mercury. These tests yielded new information on the physiological limitations of high transverse g, methods of recording anthropomorphic measurements, effects of noise and vibration on humans, body responses to heat stress, frequency of heart murmurs during heat stress, physiological and biochemical responses occurring during 1-hour MC-1 tests, physiological responses during vigorous exercise, and interpretation of psychological and psychiatric testing. Data on candidate performance are presented. The final candidate recommendation meeting is described. This report describes the methods which were used to correlate biomedical data statistically. A list of possibly significant correlations between various tests is included.

In the final candidate recommendation psychological attributes outweigh physiological attributes. Potentially fruitful areas for future experimentation are discussed.

ADMINISTRATION AND LIAISON PERSONNEL

DON FLICKINGER
Brig. General, USAF, MC
Special Assistant for Bioastronautics

and

JACK BOLLERUD
Colonel, USAF, MC
Director of Life Sciences Division

Hq. Air Research and Development Command
Washington, D. C.

and

JOHN P. STAPP
Colonel, USAF, MC
Chief, Aerospace Medical Laboratory
Wright Air Development Center
Wright-Patterson Air Force Base, Ohio

and

STANLEY C. WHITE
Lt. Colonel, USAF, MC
NASA Space Task Group
Langley Air Force Base, Virginia

JOHN D. HOWE
Brig. General, USAF
Commander

and

TRUMAN H. BALDWIN
Colonel, USAF
Director of Personnel and Base Services

Wright-Patterson Air Force Base, Ohio

and

WALTER B. SULLIVAN, JR.
1st Lieutenant, USAF
Aerospace Medical Laboratory
Wright Air Development Center
Wright-Patterson Air Force Base, Ohio

CONTRIBUTORS

WILLIAM S. AUGERSON
Captain, USA, MC
NASA Space Task Group
Langley Air Force Base, Virginia

and

MISS THERESA A. FRICKE
Data Processing
University of Dayton
Dayton, Ohio

CHARLES BERRY
Major, USAF, MC
Department of Aviation Medicine

and

CLYDE KRATOCHVIL
Major, USAF, MC
Department of Physiology

School of Aviation Medicine
Randolph Air Force Base, Texas

C. WESLEY DUPERTUIS, M. D.
Western Reserve University
Cleveland, Ohio

and

DAVID K. TRITES, Ph. D.
WADC Personnel Laboratory
Lackland Air Force Base, Texas

H. B. HALE, Ph. D.
Department of Physiology

and

BRYCE O. HARTMAN, Ph. D.
Department of Psychology

School of Aviation Medicine
Randolph Air Force Base, Texas

WILLIAM O'CONNOR
Lieutenant jg., USN
Department of Psychology
USN School of Aviation Medicine
Pensacola, Florida

and

A. H. SCHWICHTENBERG
Brig. General, USAF, MC (Ret.)
Department of Aviation and Space Medicine
Lovelace Foundation
Albuquerque, New Mexico

and

G. DOUGLAS TALBOTT, M. D.
Consultant Internist
Dayton, Ohio

THE AEROSPACE MEDICAL LABORATORY INVESTIGATING PANEL

WILLIAM R. TURNER
Lt. Colonel, USAF, MC
Chairman of the Candidate Evaluation Committee

CHARLES L. WILSON
Captain, USAF, MC
Candidate Evaluation Program Task Officer

ACCELERATION TESTS

Evan F. Lindberg, Captain, USAF, MC,
Principal Investigator

Alvin S. Hyde, Captain, USAF, MC,
Associate Investigator

Neil Cherniack, Captain, USAF, MC,
Associate Investigator

Lawrence M. Berman, 1st Lieutenant, USAF,
Biochemist

Mrs. Julia Pettitt,
Biochemist

ANTHROPOLOGICAL MEASUREMENTS

Charles E. Clauser,
Principal Investigator

Robert S. Ziegen, Captain, USAF,
Associate Investigator

Kenneth W. Kennedy,
Associate Investigator

BIOLOGICAL ACOUSTICAL TESTS

Ronald G. Hansen, Captain, USAF,
Principal Investigator and Speech Intelligibility Associate Investigator

Jack E. Steele, Major, USAF, MC,
Noise Investigator

Donald J. Baker,
Speech Intelligibility Investigator

Rolf R. Coermann, Ph. D.,
Physicist, Vibration Associate Investigator

Edward B. Magid, Captain, USAF, MC,
Vibration Associate Investigator

PHYSICAL FITNESS TESTS

Charles L. Wilson, Captain, USAF, MC,
Principal Investigator

Edmund B. Weis, Jr., Captain, USAF, MC,
Associate Investigator

Joseph Young, SSgt, USAF,
Assisting Investigator

THERMAL TESTS

Joseph Gold, Captain, USAF, MC
Principal Investigator

Johannes W. Polte
Associate Investigator

PSYCHOLOGICAL TESTS

George E. Ruff, Captain, USAF, MC
Principal Investigator

Edwin Z. Levy, Captain, USAF, MC
Associate Investigator

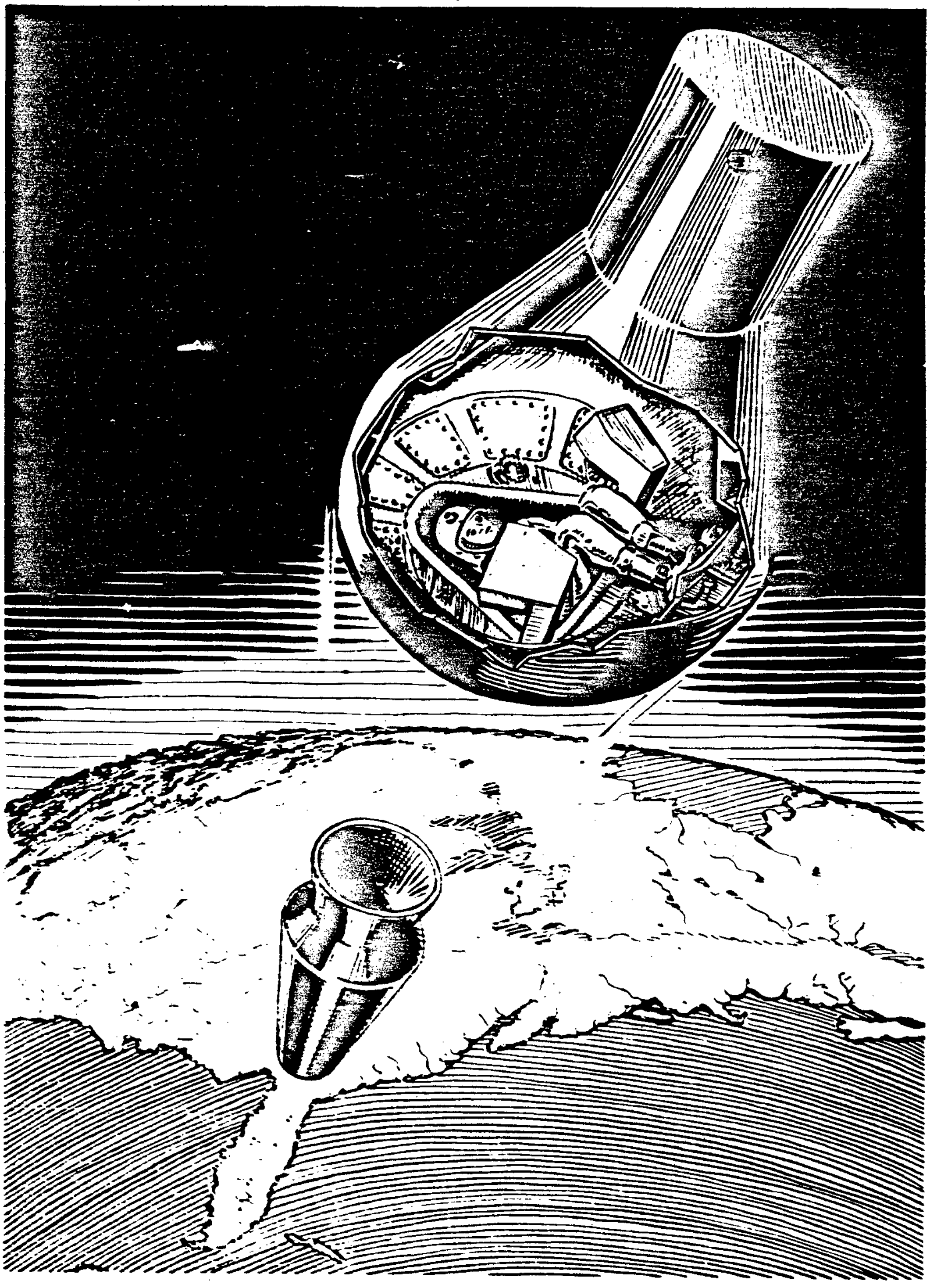
Victor H. Thaler, Captain, USAF
Psychological Investigator

John K. Jackson, Captain, USAF
Psychological Investigator

Mildred B. Mitchell, Ph. D.
Psychological Investigator

Gilbert E. Johnson, 1st Lieutenant, USAF
Psychological Investigator

TABLE OF CONTENTS



INTRODUCTION

C. L. Wilson, Capt., USAF, MC

The National Aeronautics and Space Administration (NASA), a U.S. Government civilian agency, has been assigned the task of exploring the feasibility of space travel. As a result of thorough and exhaustive study, NASA has concluded that certain aspects of space travel are feasible and, furthermore, that some will be practicable in the very near future. One profile of space travel envisions that a human pilot, transported in a life support system (capsule), could be thrust into orbit by a liquid fuel rocket, maintained there for several revolutions around the earth, and successfully and safely recovered from orbit. Project Mercury intends to realize this vision.

Among the many strategic questions to be answered is: "Who will the pilot be?" This report describes how and why the Aerospace Medical Laboratory participated in the selection of the seven Mercury Astronauts.

HISTORY

The Human Factors Division of the Air Research and Development Command (ARDC) has been keenly aware of the need for clarification of the parameters of human endurance, safety, and comfort during periods of unusual stress. In 1952 Brig. Gen. Don Flickinger, USAF, MC, began directing biomedical research toward the development of tests to assist in selecting pilots for special research projects. Under his guidance Capt. T. F. McGuire, USAF, MC, of the Aerospace Medical Laboratory, employed a series of physiological, psychological, and biochemical tests which were incorporated into a stress-test program. Dr. McGuire's experience extended over a 4-year period, during which time he tested several special groups. These included USAF pilots and young volunteers from the University of Dayton. In his final months at the Aerospace Medical Laboratory he stress-tested 12 USN underwater demolition men (frogmen) kindly loaned by the Underwater Demolition Unit II, Little Creek, Virginia. The results of his research are presented in Stress Tolerance Studies, Part I,[0.1] and Tolerance to Physical Stress, Part II.[0.2] Part III is being completed and will contain a supportive bibliography. Dr. McGuire rightfully should receive credit for his work in this field and development of early prototype crew selection profiles. Several new tests have been made available since then and are discussed later.

Captain F. J. Leary, USAF, MC, of the Aerospace Medical Laboratory also gained considerable experience in candidate evaluation. His research brought about modification of the cold pressor test to its present form. Previous testing utilized the immersion of one foot, then both feet. He also studied the reproducibility of physiological response on the same subject when tested on different days. He developed early scoring techniques based on physiological response. Modifications of his techniques were employed in the Mercury Candidate Evaluation Program.

Captain W. S. Augerson, USA, MC, was immensely valuable in the development of the final test profile. He assisted in a review of literature, experienced the actual tests, and offered valuable opinions on areas where improvement was indicated.

Two assistant investigators during the period of 1957 to 1958 were Gardner Edwards, M.D. (then a University of Virginia medical student on a USAF-sponsored scholarship), and Robert McAdam, associate professor of physical education, Northern Illinois University.

APPROACH TO THE PROBLEM OF CANDIDATE EVALUATION

The ultimate purpose of any crew recommendation development program is to devise and validate tests which can be used with reliability in selecting crew members for future projects. The Project Mercury Candidate Evaluation Program was an important stage in this ARDC development program. Since the actual approach to this research problem departs from the ideal approach, it will help to present both the ideal and actual methods of attack.

Ideal Approach to Problem:

1. The candidates must be medically acceptable and technically capable before they will be considered as potential candidates.

2. Those who are tested must be the actual project candidates. A large candidate population will increase the reliability of the results.

3. The test profile must simulate all aspects of the stresses anticipated during the actual project. The simulated stresses must be combined in the same relationship and intensity as they would occur during the project.

4. A battery of nonsimulating but relevant tests must be included in the testing program. These tests will be used to identify significant correlations between the response to simulating and nonsimulating tests. The ultimate goal is to replace simulating tests with the more easily administered, nonsimulating tests in future programs.

5. In the final recommendation of candidates, the investigators must only interpret subject performance on the simulating tests. Nonsimulating test performance will not affect recommendation of this first group of candidates.

6. All candidates, both recommended and not recommended, must enter the project.

7. At the completion of the project all of the participants must be graded on the effectiveness of their performances.

8. The investigators must then seek significant correlations between subject performances on the various simulating and nonsimulating tests and successful mission performances.

9. Those nonsimulating tests bearing significant correlation with successful mission performances may then be used to select future subjects from an identical population for identical projects. These future crew members will be highly reliable risks in successfully completing their missions. This is the goal of all endeavors at crew selection.

Actual Approach to Problem:

Inherent errors are frequently introduced when making a transition from an ideal to an applied test program due, for example, to time limitations, accelerated schedules, or unforeseen changes. The actual approach to the problem is stated below, preceded by an underlined restatement of the ideal approach:

1. <u>The candidates must be medically acceptable and technically capable before they will be considered as potential candidates.</u> The candidates were medically acceptable and technically capable. They met the following requirements: a. were pilots in the Department of Defense, b. had received engineering degrees, c. had successfully graduated from a military test pilot school, d. had achieved at least 1500 hours of total flying time, and e. each man's height was 5'11" or less. One hundred and ten men met the above requirements. Sixty-nine of these men were invited to a

NASA briefing where the detailed plans of Project Mercury were revealed. The subjects were then asked if they desired to volunteer as competitive candidates. Fifty-five of them volunteered.

2. Those who are tested must be the actual project candidates. A large candidate population will increase the reliability of the results. Those who were tested actually were the Project Mercury candidates. The 55 men who were accepted were given a series of interviews and psychological tests. On the basis of the data thus obtained, 32 were chosen for the final phase of the selection program. The 32 candidates were sent to the Lovelace Foundation, Albuquerque, New Mexico, for extensive medical histories, physical examinations, and biochemical and physiological tests.* A large random candidate population was not used. If the candidate population had been larger it would have been impossible to process them in time to meet the close time schedules of the project.

3. The test profile must simulate all aspects of the stresses anticipated during the actual project. It was impossible to devise a laboratory situation which exactly duplicated the stresses anticipated during Project Mercury. A rational alternative approach was to list the anticipated stresses and to use what laboratory tools were available.

Anticipated Stresses:

a. The men who were chosen could expect a 2- to 3-year period of intensive training including a study of space-frame structures, propulsion, inertial guidance, systems reliability, aerodynamics, and physiology. They would actively participate in training exercises such as: physical fitness, capsule parachute landings, ballistic trajectory flights, and underwater escape from capsules. These represent a prolonged period of genuine stresses.

The best practical laboratory tools to test these areas were: (1) review their past accomplishments, (2) extract personal histories, and (3) conduct psychiatric interviews and psychological tests. Additional information could be derived from observation of these candidates during moments of calibrated hazing such as: acceleration, pressure suit testing, immersing feet in ice water, and isolating the subject. The accumulated impressions of these trained observers should guarantee highly reliable maturity in those recommended.

b. Psychological and physical stresses will exist before, during, and after each flight. The psychological stresses will include fears and anxiety about possible accidents or death. Although well disguised in the mature test pilot, they will be present. The psychiatric evaluation should reveal those who are stable and reliable.

The physical stresses of blast-off and orbit will include acceleration, noise, vibration, weightlessness, tumbling if stabilization is not achieved, and possible capsule depressurization. Those insults of re-entry will contain deceleration, noise, vibration, and heat if the cooling system fails. Landing will be accompanied by deceleration. Before recovery there is the possibility that the capsule will sink. There is also the possibility of isolation in a remote and uninhabitable climate and topography.

The physical facilities available at the Aerospace Medical Laboratory are able to duplicate the important physical and psychological stresses mentioned above. These facilities include: human centrifuge, extremely low-pressure (high-altitude) chamber, heat-controlled test rooms, equilibrium-vibration chair, intense noise generator, aircraft (C-131B) specially modified to safely fly Keplerian trajectories (weightlessness), tumbling turntable, psychiatric interviewing rooms, and anechoic chamber.

Simulating Tests:

Those tests simulating stresses anticipated during Project Mercury are: transverse g profiles (acceleration tests) and vibration-equilibrium and intense noise profiles (biological acoustical tests). Weightlessness tests were not performed on the candidates for one main reason: it

* The tests performed at the Lovelace Foundation are detailed in the Appendix.

would have been impossible in scheduling always to meet the minimum flying safety requirements for each flight each day for 6 weeks. Tumbling tests are so unpleasant and the nausea so prolonged as to warrant its exclusion for the profile.

4. The simulated tests must be combined in the same relationship and intensity as they would occur during the project. The physical separation of test facilities rendered it highly impractical to improvise superimposed stress. While a multistress facility was desirable, it was not mandatory for study of the candidates. In any interpretation, partial data when expertly gathered is much more desirable than no data at all. This reasoning serves to defend the approach that was finally taken.

5. A battery of nonsimulating but relevant tests must be included in the testing program. These tests must be easy to administer and safe. A battery of easily administered and safe nonsimulating tests was incorporated into the program. They were (physical fitness tests): Harvard step, Flack, cold pressor, and tilt table. A battery of more complex nonsimulating tests was also devised. The investigators believed these might correlate significantly with simulating tests. The complex tests cannot be easily and/or safely administered. These tests are: positive g to blackout (acceleration); extensive anthropometric and photogrammetric measurements, somatotyping (anthropological); urinary catacholamines, plasma corticosteroids, urinary 3-methoxy-4-hydroxymandelic acid (biochemical); speech intelligibility (biological acoustical); 2 hours of heat stress (thermal); treadmill, MC-1 partial pressure suit (physical fitness); all tests administered (psychological); and maximum breathing capacity, bicycle ergometer, electrical stimulation of muscles (Lovelace Foundation).

6. In the final recommendation of candidates the investigators must only interpret subject performance on the simulating tests. Nonsimulating test performance will not affect recommendation of this first group of candidates. Some of these nonsimulating tests were interpreted and did affect the recommendation of candidates. This was intentional. The sum total of data gathered from all of the simulating tests, although valuable, was insufficient to render candidate recommendations with confidence. However, the investigators agreed that, if they were also allowed to interpret some of the nonsimulating tests with which they were intimately familiar, they could then attach great confidence to the final recommendations. It was unanimously agreed that each investigator-group would be allowed to interpret the nonsimulating tests which they chose. The main goal of this particular crew selection development program was to recommend outstanding candidates. An important but secondary goal was to discover the existence of significant correlations. It was unsound practice to omit data or impressions which might possibly affect the success of Project Mercury. Those nonsimulating tests which were interpreted and which did affect the final candidate recommendations were: positive g (acceleration); index of strain (thermal); Harvard step, Flack, cold pressor (only if feet were prematurely withdrawn), treadmill, MC-1 partial pressure suit (if subject terminated test for psychological reasons), tilt table (physical fitness tests); and all tests administered (psychological).

Those nonsimulating tests which were not used in the final candidate recommendations were: all measurements (anthropological); all measurements (biochemical); speech intelligibility (biological acoustical); and cold pressor test development of hypertension and/or tachycardia, MC-1 test development of presyncope or tachycardia >160, Valsalva overshoot, and tilt table (physical fitness tests).

7. All candidates both recommended and not recommended must enter the project. All of the candidates did not enter the project. The final selection took into consideration all of the assets of the candidates. These assets included past training, experience, recommendations from the Lovelace Foundation, and recommendations from the Aerospace Medical Laboratory (AML).

8. At the completion of the project all of the participants must be graded on the effectiveness of their performances. The above condition has not been satisfied as this report nears completion. It will require several years to satisfy this condition.

9. The investigators must then seek significant correlations between subject performances on the various simulating and nonsimulating tests and successful mission performances. Since condition

8. is not satisfied, this condition also cannot be satisfied. An alternative approach has been used. It has been assumed that the Mercury Astronauts are the best potential group to fulfill the mission of Project Mercury. It has also been assumed that they will carry out the mission successfully. There is confidence that these assumptions will mature into fact. Based upon these assumptions a significant correlation study has been sought. Ideally, it is premature. Practically, it is valuable, since the program has demonstrated tests that should be pursued in future crew recommendation studies.

Each chapter has been written by the appropriate principal investigator. Throughout this report the candidates will be referred to by alphabet letters assigned to their names. There is no relationship between these alphabetical designations and their names or NASA numbers. It is impossible for the reader to identify a particular subject's name or performance. This system was designed to maintain the privileged communication due each candidate.

REFERENCES

0.1. McGuire, T. F. Stress Tolerance Studies, Part I. Unpublished Data. 1958.

0.2. McGuire, T. F. Tolerance to Physical Stress, Part II. Unpublished Data. 1958.

CHAPTER I

CANDIDATE ARRIVAL, BRIEFING, AND SCHEDULING

The Project Mercury candidates completed their extensive examinations at the Lovelace Foundation early on a Saturday morning. Their complete records accompanied them as they departed via airlines for Dayton, Ohio.

They arrived in groups of five in Dayton at approximately midnight, reported to the airlines office, and asked for Lt. Col. Turner (their means of being identified). The administrative assistant escorted them to Wright-Patterson Air Force Base, where they were all billeted in a single house. They were advised that they would be briefed at 10:00 a.m. on Sunday morning.

The briefing was conducted by the laboratory coordinator, the administrative assistant, the task officer, another investigator from the Physical Fitness Test Unit, and an investigator from the Psychology Test Unit.

Details Discussed:

1. The tests which the candidates would receive had been devised for two purposes: first, interpretation of performance would assist in recommending those candidates who were outstanding in the tests; second, some of the tests had been included which would not be used in the candidate evaluation but which would be analyzed later to establish the presence or absence of significant correlations between interlaboratory tests. The candidates were urged to perform to the best of their ability and not to be discouraged if on any particular test they performed less well than they anticipated. It was pointed out that these tests are not easy to accomplish, and that a single poor performance very rarely carries a heavy penalty in the final scoring. They were reminded that the final selection of Mercury Astronauts would be made by NASA and that the AML's function was to render recommendations on all of the candidates. They were reassured that, although stressful, all of the tests are safe, and that each investigator had experienced his particular stress test several times to familiarize himself with the nature and severity of the stresses. The candidates were cautioned to report any illnesses so that proper medical attention could be provided and that test rescheduling would be accomplished when the subject was well.

2. The candidates were advised that none of the medical, psychological, or performance records would be included in their personal flight records unless they specifically requested that the records be included. The main purpose of the exclusion of Project Mercury records from the Department of Defense (DOD) pilot medical records was to guarantee that any episode of syncope (which might occur, for example, on the human centrifuge, the MC-1 test, or the tilt table test) would not be a threat to the pilot's flying status. They were solicited for recommended changes they believed might enhance the reliability of future programs. Finally, they were asked not to discuss the administration of or their performances on any test with the other candidates.

3. The task officer then briefed the candidates on what tests would be given. Lantern slides and a projector were used as an aid. The following slides were shown and very briefly discussed:

a. Psychiatric interview

b. Rorschach test

c. Positive g profile

d. Transverse g profile

e. Anthropometric studies

f. Heat test

g. Harvard step test

h. Flack and Valsalva overshoot test

i. Treadmill test

j. MC-1 partial pressure suit test

k. Tilt table test

l. Equilibrium chair test

m. High-energy sound test

n. Recommendation committee's meeting

The cold pressor test was not mentioned so that it would be a total surprise to all of the candidates.

4. The medical officers on the briefing committee then reviewed the medical records which had accompanied the candidates. When it was determined that the candidates were medically acceptable, each man was assigned an AML number from 1 to 5. Then the administrative assistant briefed them on their individual schedules (see figure 1.1). When all of the questions of the candidates had been answered, the briefing was adjourned.

SUNDAY

10-11	Briefing
12-2	Lunch
2-6	Psych

MONDAY

	#1	#2	#3	#4	#5
8-9	Psych	Psych	PF	Psych	PF
9-10	Acc	Psych		Psych	
10-11	Anth	Acc		Psych	
11-12	Anth	Free		Acc	
			LUNCHEON		
12:30	PF MC-1	Heat	Psych Iso	Acous	Psych CBS
			DINNER		
7-9:30	PSYCHOLOGICAL TESTING				

TUESDAY

	#1	#2	#3	#4	#5
8-9	PF	PF	Psych	Psych	Psych
9-10			Acc	Psych	Psych
10-11			Anth	Acc	Psych
11-12			Anth	Free	Acc
			LUNCHEON		
12:30	Psych Iso	Psych CBS	PF MC-1	Heat	Acous
			DINNER		
4:30			FREE		

WEDNESDAY

	#1	#2	#3	#4	#5
8-9	Psych	Psych	Psych	PF	PF
9-10	Psych	Acc	Psych		
10-11	Acc	Anth	Psych		
11-12	Free	Anth	Acc		
			LUNCHEON		
12:30	Heat	PF MC-1	Acous	Psych CBS	Psych Iso
			DINNER		
7-9:30	PSYCHOLOGICAL TESTING				

THURSDAY

	#1	#2	#3	#4	#5
8-9	Psych	PF	PF	Psych	Psych
9-10	Psych			Acc	Psych
10-11	Psych			Anth	Acc
11-12	Acc			Anth	Free
			LUNCHEON		
12:30	Acous	Psych Iso	Psych CBS	PF MC-1	Heat
			DINNER		
4:30			FREE		

FRIDAY

	#1	#2	#3	#4	#5
8-9	PF	Psych	Psych	PF	Psych
9-10		Psych	Psych		Acc
10-11		Psych	Acc		Anth
11-12		Acc	Free		Anth
			LUNCHEON		
12:30	Psych CBS	Acous	Heat	Psych Iso	PF MC-1
			DINNER		
7-9:30	PSYCHOLOGICAL TESTING				

SATURDAY

	#1	#2	#3	#4	#5
9-10:30	PSYCHOLOGICAL TESTING				
10:30	DEBRIEFING				

Acc = Acceleration
Anth = Anthropology
Acous = Biological Acoustics
Heat = Heat
PF = Physical Fitness
Psych = Psychology
MC-1 = Partial Pressure Suit
Iso = Isolation
CBS = Complex Behavioral Simulator

Figure 1.1. Weekly Schedule Chart

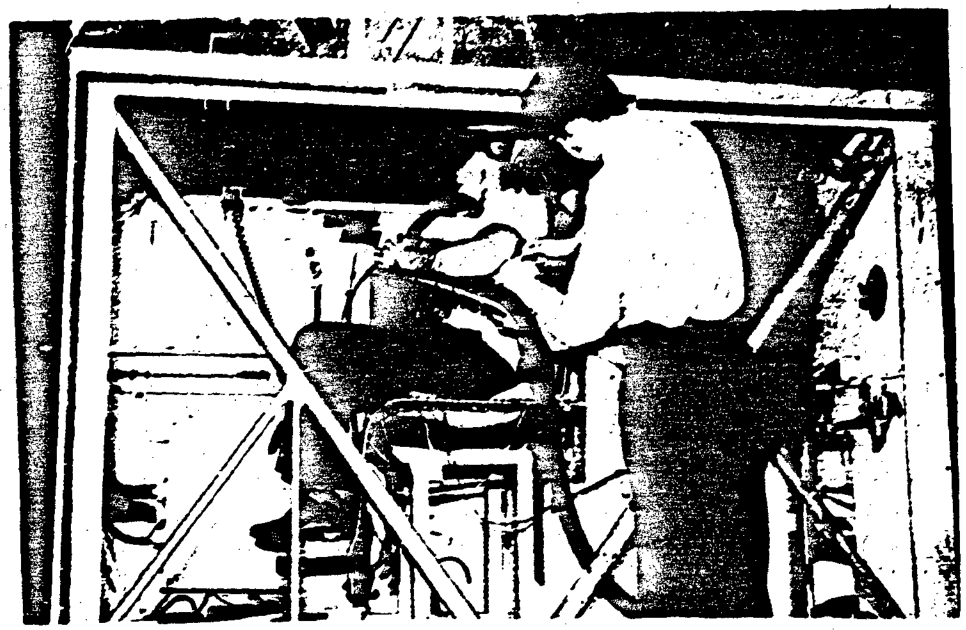


Figure 2.1. Centrifuge Test, Seated Position, Positive "g" Profile. Note Tube to Mouth for Vital Capacity. Goggles Shield against Windblast.

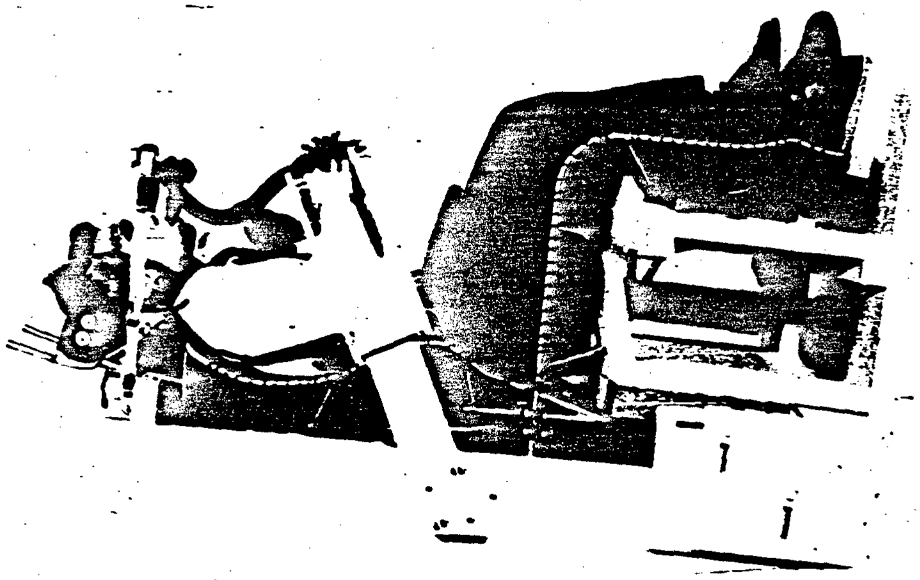


Figure 2.2. Centrifuge Test, 12° Angle with Respect to the Inertial Force Vectors, Positive "g" Profile

CHAPTER II

ACCELERATION TESTS

PART 1.

E. L. Lindberg, Capt., USAF, MC

INTRODUCTION

During the initial planning of the testing program for the Project Mercury candidates, it was hoped that each subject's response to acceleration would be evaluated in terms of physiological tolerance. Until a few years ago, only headward accelerations (so-called positive acceleration) experienced by subjects in a seated position (figure 2.1) were of operational interest. The physiological alterations which determine a man's capability during positive g take place primarily in the cardiovascular system.[2.1, 2.2, 2.3] As headward acceleration increases, the cardiovascular system experiences difficulty in maintaining adequate blood flow to the eyes and brain, and the subject experiences visual blackout and finally unconsciousness. It would appear that physiological tolerance to this type of acceleration could be determined on the basis of the visual blackout level.

A recent study[2.4] pointed out the variables which affect such a determination: the rate of onset of acceleration, the exact position of the subject in relation to the force vectors, the degree of relaxation achieved by the subject, the intensity and color of the light, and the psychological status of the subject at the moment of the stress. For purposes of tolerance determinations, two of these variables could not be standardized: the degree of subject relaxation and the psychological status of the subject. Even in the relaxed, experienced centrifuge rider the day-to-day variation in visual blackout level may be 0.5 g-units with gradual rates of onset, and purposely induced anxiety may raise this level by as much as 1.5 g's. Use of the subjective endpoint of visual blackout as an indication of the physiological limit, in the presence of uncontrolled variables, is unsound.

Added to these problems is the recent interest in man's ability to withstand much higher accelerations. Recent work[2.5] has shown that a subject in a nylon-net, seat-restraint system, his trunk elevated to a 12° angle with respect to the inertial force vectors (figure 2.2), can be accelerated to 16.5 g's for short periods of time without serious impairment of vision or manual dexterity. In this case, with the subject facing the direction of acceleration, this is referred to as forward acceleration. Information regarding the response of Project Mercury candidates to this type of acceleration would certainly be desirable. In this position the physiological alterations take place, primarily, as a result of decreased respiratory function. As the acceleration is increased it becomes more difficult to expand the chest against the inertial force, and the viscera press against the diaphragm preventing movement, until finally effective respiration ceases altogether at 10 to 12 g's and hypoxia occurs. To measure the exact point at which respiration ceases requires special instrumentation which is not applicable to large groups of subjects in a short period of time. A distinct endpoint upon which to base an objective determination of physiological tolerance to forward accelerations, is lacking. For these reasons it was decided that physiological performance would be evaluated during both headward and forward acceleration.

METHOD

The Aerospace Medical Laboratory human centrifuge was used to produce the desired accelerations. The subject on the centrifuge was supported by a nylon-net seat which could be adjusted to the various positions discussed below. To evaluate the decrement in respiratory function during acceleration, the subject's vital capacity was measured at different levels of g. Large bore rubber tubing was used to connect the subject's mouthpiece to the collecting chamber of a respirometer mounted in the centrifuge cab. A switching system, incorporated into this tubing, allowed the subject to divert his breathing from room air into the respirometer. On prearranged signals the subject inhaled as deeply as possible on room air, switched to the respirometer circuit, exhaled quickly and maximally, and then switched back to room air. Movement of the counterbalanced respirometer bell was recorded electrically and a direct write-out made through a Sanborn recorder. Volumes read from these records were accurate within 50 ml.

An electrocardiogram was continuously recorded while the subject was on the centrifuge. Heart rates were taken from these records; and all abnormalities in cardiac rhythm were recorded. One further evaluation of the cardiovascular system was made during headward acceleration. A level of visual blackout was determined with the subject instructed to use any method of straining, muscle tensing, and/or M-1 maneuvers to which he was accustomed as the acceleration was increased. This level was recorded when the subject failed to answer an intermittently triggered light which was at eye level in the subject's control field of vision. An arbitrary limit of 9 g's was felt to be necessary for this test, since the margin of difference between the levels of blackout and unconsciousness becomes small above 8 g's.

The acceleration profiles which were used are shown in figure 2.3. The subject experienced the headward acceleration profile on one day and the two forward acceleration profiles on another. The rate of onset for the headward acceleration was 1 g every 15 seconds to allow adequate time for compensatory cardiovascular reflexes to have effect. At the 5-g plateau the subject's vital capacity was recorded. Then, with the subject straining, tensing his muscles, and performing the M-1 maneuver, the acceleration was increased to the level of visual blackout. The rate of onset for both forward accelerations was 1 g every 5 seconds. For the first forward acceleration exposure the subject's back formed a 90° angle with the inertial force. The vital capacity was measured at the 5-g and 8-g plateaus. The second transverse profile had plateaus at 5 g's, 8 g's, and 12 g's for vital capacity measurements. The back angle was elevated 12° in the direction of the acceleration vector.

SCORING

The data obtained during acceleration was compared with that obtained during the prerun control period with the subject in the centrifuge cab in each of the respective positions. As a basis of comparison of one subject with another, the changes in vital capacity at the different levels of acceleration were expressed as percents of the control value. The absolute levels of blackout and the heart rate at 5 g's during headward acceleration were also compared.

Each of eight separate physiological responses was compared with the mean response for the entire group. The blackout level was weighted twice in scoring. If the performance value was greater than 1 σ above the mean, the subject was given 1 point. If the value fell within 1 σ of the group mean, a half point was given. If any value was less than 1 σ below the mean, no points were given. A sample of one group's scoring is shown in table 2.1.

RESULTS

The average change in vital capacity at the different levels of acceleration and for different positions is shown in tables 2.2 and 2.3. The experienced members of the Wright Air Development Center centrifuge panel were exposed to the same acceleration profiles as the Project Mercury candidates to afford a baseline for comparison of the results. It has been shown that the average tidal volume during normal respiration represents 10% to 15% of the vital capacity. The average subject's vital capacity at 8 g's was 12% to 15% of his control vital capacity, which means that his maximum breathing effort at 8 g's is quantitatively equal to his normal tidal volume. Contrary to the subjective

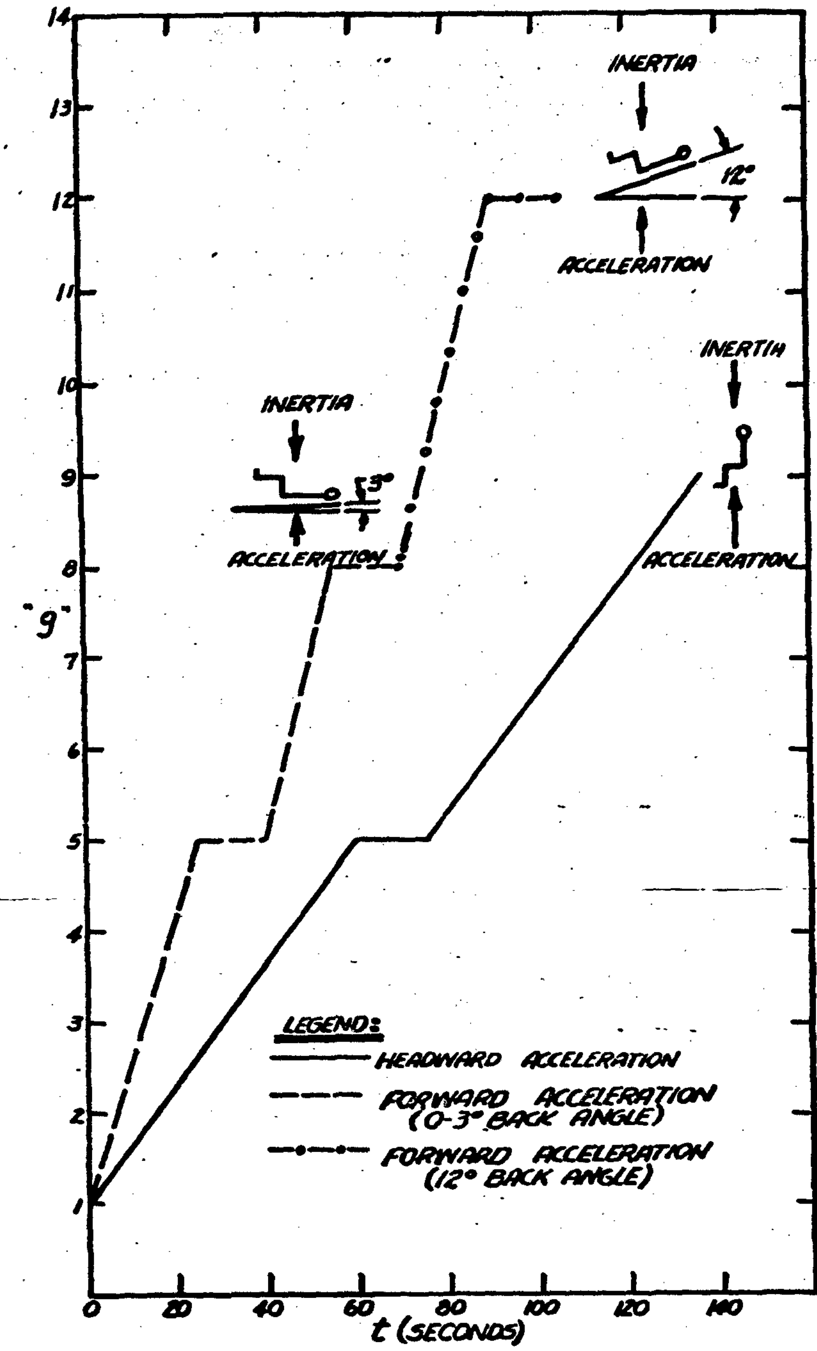


Figure 2.3. Acceleration Profiles Used on Project Mercury Candidates

TABLE 2.1

RESULTS FROM ONE GROUP OF NASA PROJECT MERCURY CANDIDATES
(Scoring Points Are Shown)

Subject	Blackout Level		Pulse Rate Positive Position		Percent of Control Vital Capacity Remaining												Total Score 0 to 9
					Positive Position		Supine Position				Semisupine Position						
	g's		5 g's		5 g's		5 g's		8 g's		5 g's		8 g's		12 g's		
	v*	s**	v	s	v	s	v	s	v	s	v	s	v	s	v	s	
EE	7.5	1	200	0	59	1/2	49	1/2	16	1	49	1	15	1/2	4	1/2	5.0
A	7.0	0	190	0	54	1/2	44	1/2	2	0	40	1/2	2	0	6	1/2	2.0
BB	7.5	1	135	1	25	0	44	1/2	2	0	29	0	2	0	1	0	2.5
K	8.9	2	150	1	57	1/2	53	1/2	13	1/2	51	1	21	1	0	0	6.5
L	7.1	0	150	1	55	1/2	43	0	5	0	33	0	0	0	5	1/2	2.0
D	7.6	1	200	0	68	1	57	1	21	1	56	1	19	1	8	1	7.0
Mean	7.6		170		53		49		10		43		10		4		
S. D.	0.3		18		7		5		4		4		5		3		

* Actual Value
** Scoring Points

TABLE 2.2

PERCENT OF CONTROL VITAL CAPACITY MEASURED DURING ACCELERATION
(31 NASA Subjects)

Position	5 g's		8 g's		12 g's	
	Average	Range	Average	Range	Average	Range
Positive	55%	25%-69%				
Supine (0° - 3° Back Angle)	45%	26%-87%	13%	0%-39%		
Semisupine (12° Back Angle)	43%	18%-63%	15%	0%-39%	5%	0%-19%

TABLE 2.3

PERCENT OF CONTROL VITAL CAPACITY MEASURED DURING ACCELERATION
(Centrifuge Panel Members)

Position	5 g's		8 g's		12 g's	
	Average	Range	Average	Range	Average	Range
Positive	48%	21%-69%				
Supine (0° - 3° Back Angle)	38%	27%-45%	12%	6%-35%		
Semisupine (12° Back Angle)	39%	27%-52%	12%	3%-37%	1%	0%-6%

impressions recorded in the past, the 12° increase in back angle was not sufficient to improve respiratory function in either group. At 12 g's the average maximal breathing effort is equivalent to one half of the normal tidal volume. In the future an evaluation of the diffusion ratios of oxygen at the alveolar level will lend more importance to these figures.

Although the mean values of the Project Mercury candidates were higher than those of the centrifuge panel, the differences were not statistically significant and the range of values was much the same.

The mean visual blackout level of the NASA candidates was 7.0 g's with values ranging from 5.2 g's to the arbitrary upper limit of 9 g's. As a rule, better performance was obtained from those pilots who were more familiar with the muscle tensing and M-1 procedures for anti-g protection.

The average heart rate for the NASA candidates at 5 g's during headward acceleration was 160 beats per minute with values ranging from 90 to 200 beats per minute. There was no significant correlation between heart rate at 5 g's, or the percent change in heart rate from control levels, with the blackout level. One of the subjects who reached the 9-g level before blackout had a heart rate of 200 from the time he reached 5 g's until the test was terminated at 9 g's. Another subject who had a heart rate of 200 at 5 g's was blacked out at 6.2 g's. It was concluded that the pulse rate was not an accurate index of the effectiveness of the circulatory system, but it is generally thought that a heart is inefficient in maintaining cardiac output at rates above 180. Since the degree of inefficiency at these higher heart rates has not been quantitated, no explanation is offered for the subject with a heart rate of 200 and a 9-g blackout level.

Extrasystoles were recorded during one of the profiles in 6 of the 31 subjects. None of them showed any abnormalities during more than one profile. One of these six subjects had an interpolated extrasystole after every third normal beat for a 20-second interval at 10 to 12 g's during forward acceleration. The other subjects had only occasional extrasystoles during acceleration. There were no subjective symptoms attributed to these findings, and, immediately following the acceleration, no abnormalities were demonstrated. Extrasystoles are frequently recorded on members of the centrifuge panel who repeatedly undergo acceleration.

SUMMARY

A method has been described by which a group of subjects was evaluated in terms of physiological response and performance during headward and forward acceleration. The decrement in respiratory function was determined during both types of acceleration by measuring the vital capacity. During headward acceleration the cardiovascular system's response was determined by recording the level of visual blackout. Further information regarding the cardiovascular system was obtained from the electrocardiograms recorded during the tests. To determine if the subject's lack of familiarity with acceleration, as experienced on the centrifuge, would affect the results, the same tests were performed on a panel of experienced centrifuge riders. The difference in results was not statistically significant.

Each subject's performance was compared with the mean values for the entire group, and a scoring system was designed to divide the subjects into average, above average, and below average groups. A further subdivision into an order of precedence, based on the data from these brief tests, was not felt to be warranted. It was intended that any serious physiological handicap or defect would be demonstrated during the selected profiles.

PART 2. URINARY OUTPUT OF 3-METHOXY-4-HYDROXYMANDELIC ACID

M. L. Berman, 1st Lieutenant, USAF
Julia Pettitt

INTRODUCTION

In order to confirm the recent finding that 3-methoxy-4-hydroxymandelic acid, a major urinary catabolite of both adrenaline and noradrenaline,[2.6,2.7] is correlated with the stress of acceleration,[2.8] estimation of this catabolite was made from urine collected from six of the NASA candidates. Urine samples were collected 1 and 3 hours after the following stress situations: forward acceleration, isolation, heat, simulated altitude at 65,000 feet in an MC-1 partial pressure suit, and 1 hour after the candidates were given 4 hours of psychological tests. Because there was not time in the candidate's schedule to obtain urine samples during a 3- to 4-hour period when candidates were not undergoing a test, the control level was determined from urine collected 3 hours after isolation during which time candidates were probably in the most relaxed condition. This control period occurred late in the afternoon for all candidates tested. Only those candidates whose schedule showed a 3-hour interval between each stress situation were selected for this experiment.

RESULTS

The results showed that the output of this catabolite was significantly above the control level (probability of chance occurrence less than 0.01) 1 hour after forward acceleration, exposure to simulated altitude of 65,000 feet, isolation, and the psychological test period. No significant change was observed after heat stress. The low excretion values found during this control period may be due to diurnal variation and/or exhaustion of the catacholamine catabolite following the isolation period. Current investigations will test the validity of the assumption that the 3-hour, late-afternoon period after isolation is a true control period. Therefore, the data collected on the urinary output of the catabolite for the Project Mercury candidates will be reported at a later date.

REFERENCES

2.1. Code, C. F., E. H. Wood, et al. "The Sequency of Physiological Events in Man during Exposure to Positive Acceleration." Fed. Proc. 4: 14. 1945.

2.2. Maciolek, J. A. Circulatory Reflex Activity as a G-Protective Device. WCRD TN 55-1. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. January 1955.

2.3. Zarriello, J. J., L. M. Seale, and M. E. Norsworthy. The Relationship between Cardiovascular Response and Positive G Tolerance. Project NM 11 01 11, Report No. 11. USN School of Aviation Medicine, Pensacola, Florida. 1958.

2.4. White, William J. Acceleration and Vision. WADC TR 58-333. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. November 1958.

2.5. Clarke, N. P., A. S. Hyde, et al. A Preliminary Report of Human Response to Rearward Facing Re-Entry Accelerations. WADC TN 59-109. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. July 1959.

2.6. Armstrong, M. D., A. McMillan, and K. N. F. Shaw. "3-Methoxy-4-Hydroxy-D-Mandelic Acid, A Urinary Metabolite of Norepinephrine." Biochem. Biophys. Acta. 25: 422-423. 1957.

2.7. Axelrod, J., S. Senoh, and B. Witkop. "O-Methylation of Catecholamines in vivo." J. Biol. Chem. 233: 697-701. September 1958.

2.8. Berman, M. L. "A Preliminary Report on Quantitative Estimation of Urinary Metabolite of Adrenaline and Noradrenaline as a Possible Indication of Tolerance to Gravitational Stress." J. Aerospace Medicine. (Submitted for Publication)

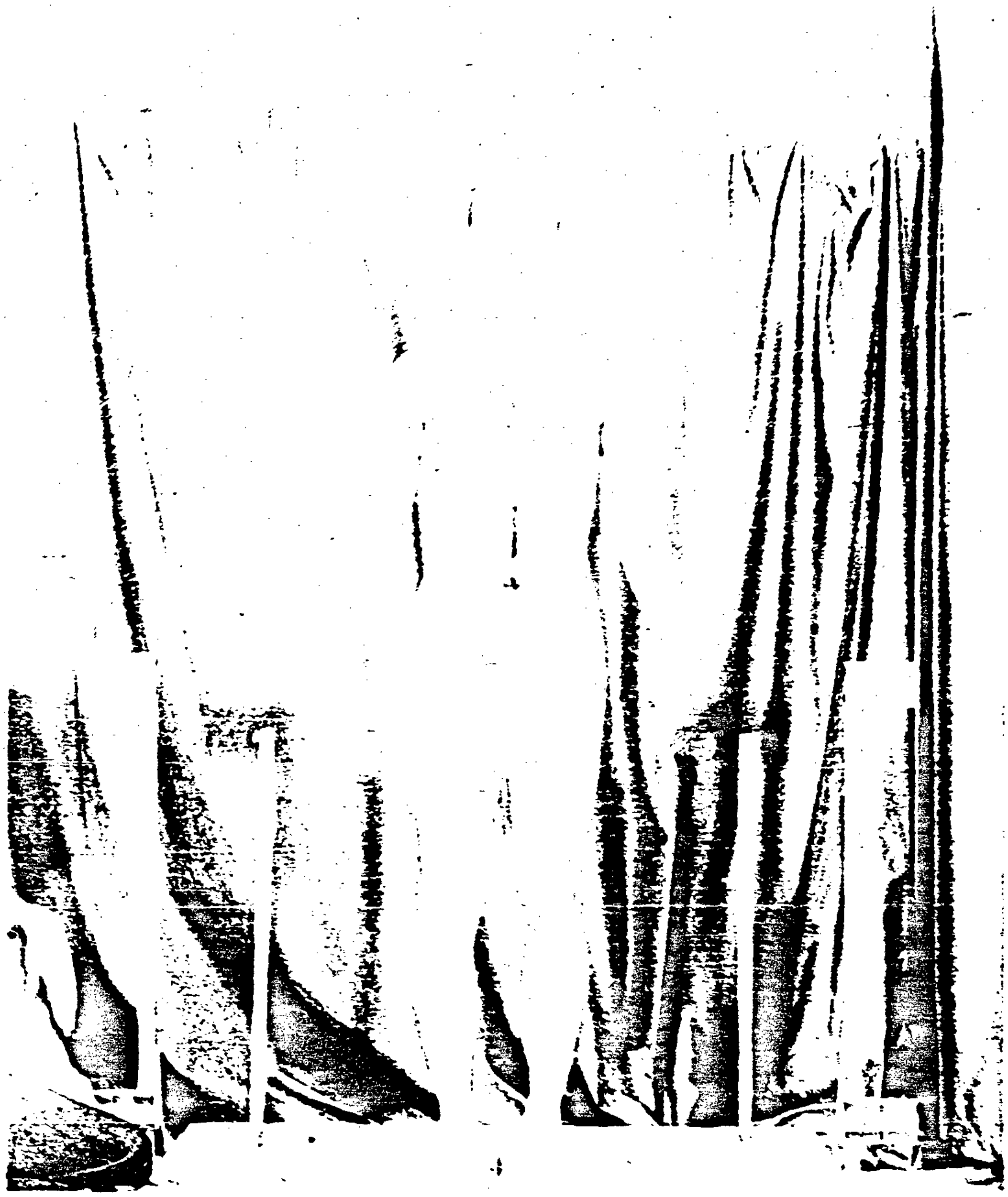


Figure 3 1. Somatotype Photograph

CHAPTER III

ANTHROPOMETRIC STUDIES*

C. E. Clauser

METHOD

The responsibility of the anthropometric investigators to the candidate evaluation program was to provide a detailed anthropometric record of each subject. This record was to be in three parts: 58 directly measured dimensions, a series of 3 standard somatotype photographs—pictures of subjects posed in a specific, standardized manner from which numerical assessments of physique are made (see figure 3.1), and a series of 4 stereophotographs (see figure 3.2). The 58 dimensions were taken to provide a metrical and proportional description of the subjects, including a calculation of lean-body weight. They were also to be used to establish workspace and clearance dimensions to assist engineers designing the Mercury capsule and equipment and to provide fitting information, if needed, for articles of personal equipment. The series of three somatotype photographs (front, left side, and rear) were taken to allow an assessment of body typology. Four pairs (right-side, left-side, front, and back views) of stereophotographs were taken of each subject. These photographs form a record of the subject from which extensive data can be extracted. Figure 3.2 is a print of one of a pair of stereophotographs. The stippling on the body furnishes sufficient surface contrast for the plotting of contour maps. The lines drawn on the body enable the contourer to join the four views of the body, and the circled crosses at various points record the level of direct circumferential measurements. Figures 3.3 and 3.4 are left-side and back contour maps of a subject. From such contour maps, cross-sectional diameters, circumferences, and areas can be determined at any level, the surface area of the total body or almost any particular part can be established, and the volume of the body or its segments can be assessed. In addition, body arcs, contours, and any desired linear dimensions can be measured. An error of 1% or less of such information derived from contour maps of the body plotted from stereophotographs has been demonstrated.[3.1]

Lean-body weight was determined using four direct dimensions —— stature, lateral chest diameter, bitrochanteric diameter, and lateral wrist diameter following a technique developed by Capt. A. R. Behnke, Jr., USN, MC.[3.2] Purported lean-body weight is the actual body weight minus the fat content with the exception of the "essential" lipids.[3.3] Thus, lean-body weight reveals the amount of "excess fat" of the body. Lean-body mass** was independently assessed on each subject by the Lovelace Foundation, through a contract with the Atomic Energy Commision of Los Alamos, New Mexico, by a sophisticated radioactive K^{40} method.[3.3] A comparison of the data obtained by the 2 methods has been made on 21 of the subjects. (Lean-body mass on the other subjects is not available to the Aerospace Medical Laboratory at the time of publication of this report.)

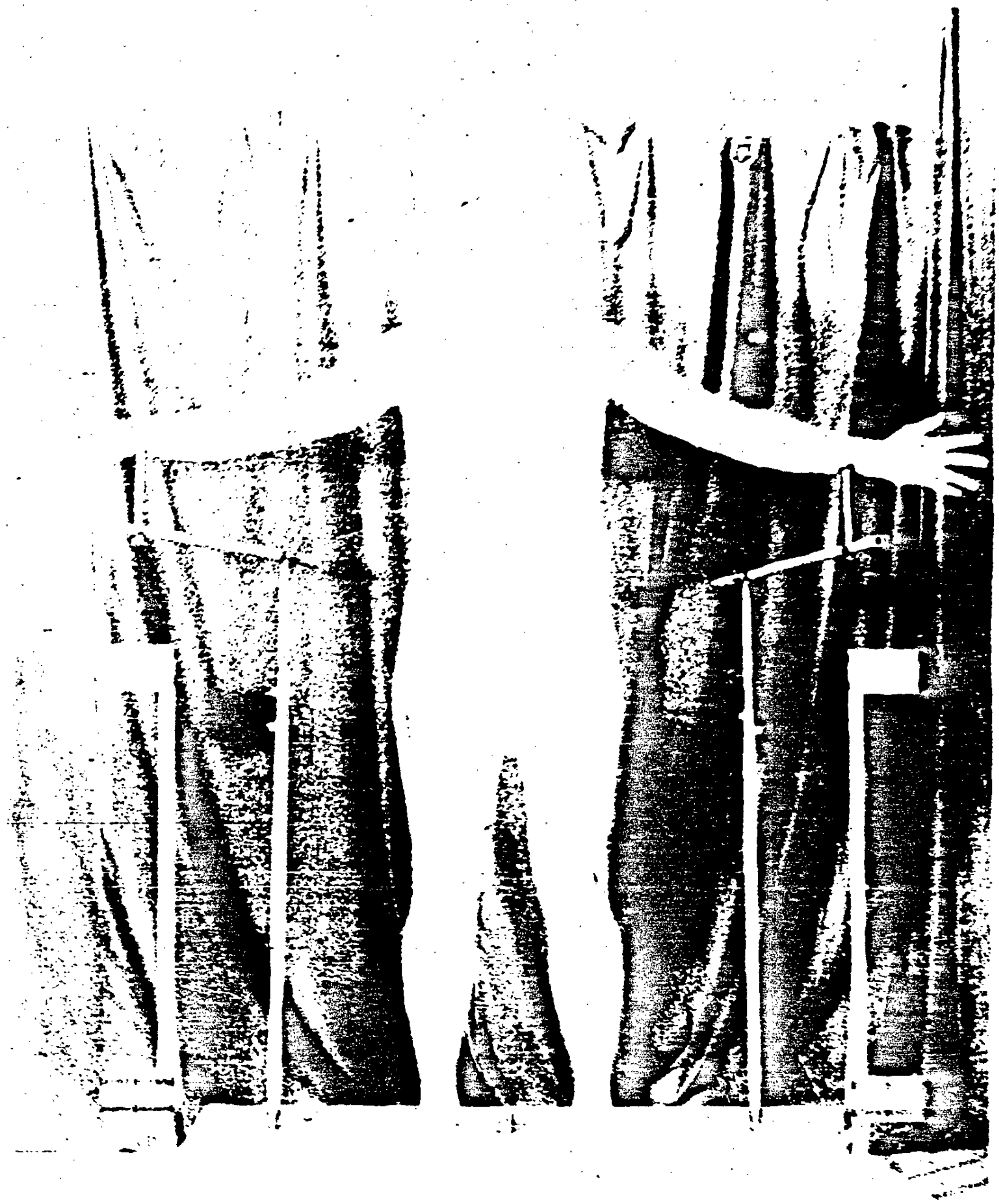
The determination of the body physique or somatotype *** follows that described by Sheldon[3.4] This system uses a scale of 1 to 7. Numerical ratings are made from an evaluation of photographs showing the degree to which the body exhibits three primary components: endomorphy (softness, roundness), mesomorphy (solidity, muscularity), and ectomorphy (linearity, delicacy). The resulting

---

* The author of this chapter wishes to thank Mr. H.T.E. Hertzberg, Chief of the Anthropology Section, Biophysics Branch, of the Aerospace Medical Laboratory, for his critical review of this chapter and his many helpful suggestions.

** For practical purposes, lean-body mass is equivalent to lean-body weight.

*** All somatotypes were made by Dr. C.W. Dupertuis of the School of Medicine of Western Reserve University.



numerical expression denotes the somatotype of the individual in degrees of endomorphy, mesomorphy, and ectomorphy, respectively. For example, the somatotype 361 indicates a body type that has a moderate degree of endomorphy, is predominately mesomorphic, and has a minimum of ectomorphy.

RESULTS

The determination of lean-body weight from anthropometric data has proved to be most interesting and of significant potential use. In general, the agreement between lean-body weight as estimated anthropometrically and the lean-body mass as estimated by K^{40} is remarkably good. A comparison of the differences of the percent of "excess" fat as determined by these 2 techniques for the 21 subjects, for which comparative data are available, showed a mean difference of 2.9%. Eleven subjects were within 0.4% to 2%, 6 subjects were within 2.4% to 4.6%, and the remaining 4 varied from 5.3% to 10.6%. Several reasons are possible to explain the larger differences. There could be an error in measuring or recording. Minor variations in the chest, wrist, bitrochanteric, and stature dimensions may significantly affect the final results. Therefore, in the future, all subjects that are to be examined as part of the continuing candidate evaluation study will be measured more than once for these dimensions and the average measurements will be used. (Remaining significant differences between the two methods should be investigated in order to see whether or not a better equation can be derived.) This portion of the study suggests that a new tool may become available for the Flight Surgeon to use routinely in assessing the conditions of his personnel.

From the analysis of body type data, the main features noted were the general uniformity of body types represented in this Project Mercury sample. All 31 showed above average development of mesomorphy or general muscular development, and the 7 selected Astronauts had still a slightly higher average for the mesomorphic component. Table 3.1 shows the means for the 3 components for a sample of 3935 Air Force flying personnel, the 31 Mercury candidates, and the 7 Astronauts.

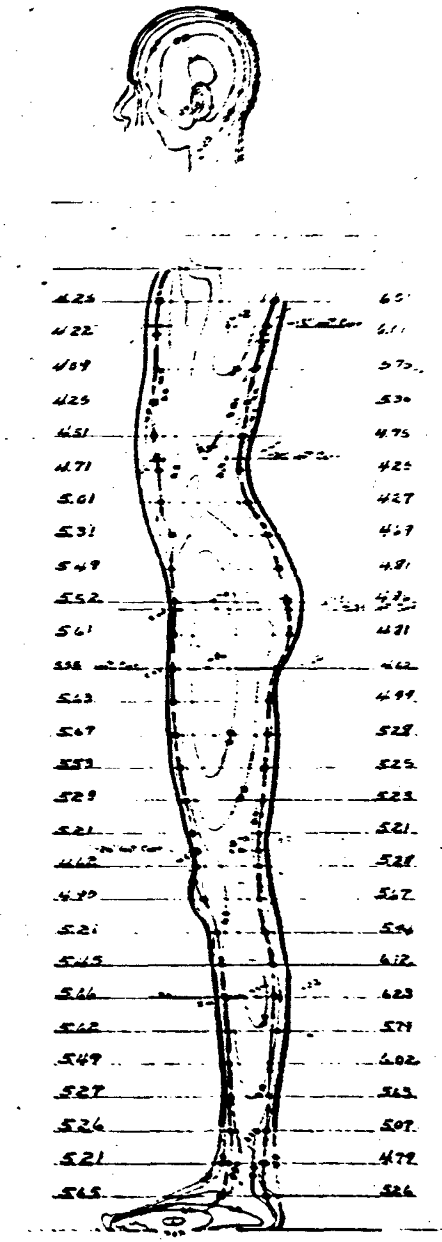


Figure 3.3 (right). Left-Side View Contour Map

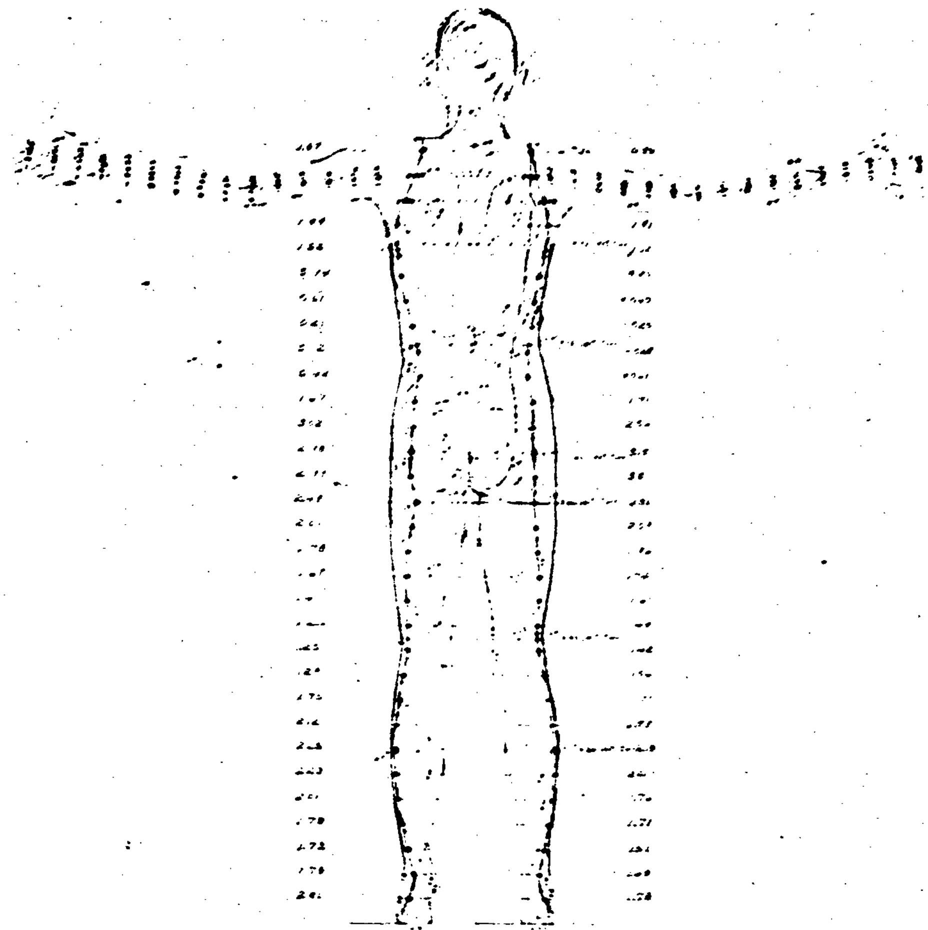


Figure 3.4. Back View Contour Map

TABLE 3.1

MEAN SOMATOTYPE COMPONENTS OF AIR FORCE FLYING PERSONNEL, MERCURY CANDIDATES, AND ASTRONAUTS

	Endomorphy	Mesomorphy	Ectomorphy
Air Force Flying Personnel[3.5]	3.47	4.51	2.95
Mercury Candidates	3.57	4.86	2.32
Astronauts	3.71	5.00	2.21

DISCUSSION

The anthropometric investigators did not attempt to rank or rate the Mercury candidates in any fashion. At present the correlation between anthropometric data and an individual's potential ability to perform a specific task is too low to justify a conclusion that one subject has a greater chance than another to carry out a given mission successfully. Several past investigations into the relationships between physique and success in military flying have had contradictory results. Some investigators reported that successful civil and military flyers were significantly taller and heavier, with above average development of muscularity, than the general population or a college population.[3.6] However, Army Air Force staff psychologists attempted to validate performance against anthropological and psychological data which were supposed to predict success in military flying. They found no association between anthropological data and success in military flying or primary flight training achievements.[3.6] Damon anthropometrically and anthroposcopically (visual inspection) measured and somatotyped 3193 flyers, 425 college students, and 57 Army Air Force soldiers. He was attempting to determine whether significant or meaningful association between anthropometric and morphological data and success in military flying could be established. In this instance, success in military flying was based on airmen with superior combat records in World War II. This study revealed from moderate to low, but statistically significant, correlations between success in military flying and chest circumference, chest circumference and stature index, head circumference and chest circumference index, and gynandromorphy (the degree to which males exhibit bodily characteristics ordinarily associated with females). This study is interesting and significant in the search for the confirmation or refutation of the thesis that success in flying can be predicted on the basis of body form and proportions. However, the factors involved in ability to perform military flying successfully are too complex to predict the superiority of one subject over another from a small group of highly proven flyers on the basis of physique. It has not yet been established if the qualities that make up a superior combat flyer are those desirable for pilots of advanced research vehicles.

The preliminary correlation study (see Appendix IV) may suggest areas of concentrated investigation. It should be emphasized that the data are insufficient as a basis for significant generalization. When the sample size of the candidate evaluation program is large enough, all items of anthropological information can be assessed against data accumulated by the participating disciplines, and promising leads revealed can be subjected to further study. Of particular interest will be an analysis of the type of data that can only be obtained from the stereophotographs.

A comparison of the somatotypes of Air Force flying personnel, Mercury candidates, and Astronauts is interesting, but no conclusions can be drawn (see table 3.1). There is an apparent increase in the mean endomorphic and mesomorphic components and a decrease in the ectomorphic component of the groups in the following order: Air Force flying personnel, Mercury candidates, selected Astronauts. A possible explanation for increased endomorphy could lie in the fact that, while the Mercury candidates are older than the general Air Force flying population, the Astronauts are older than the mean Mercury candidate population. Also, since the Mercury candidates were limited to those 71 inches or less in stature, their mean ectomorphic rating could be expected to be lower than that of the Air Force flying population. A comparison of the mean heights, weights, and ages of the Air Force flying population, the Mercury candidates, and the Astronauts is presented in table 3.2. It is interesting, but not statistically significant, that the mean stature of the Mercury sample is less than that of the Astronauts. The smaller men did not fare so well in this sample as medium-to-large men.

When the first man is orbited into space, many problems similar to those encountered in preparing man to fly conventional vehicles must be solved. The man and the machine will have to be an integrated man-machine complex. The man must fit comfortably into the capsule and be able to operate efficiently all necessary controls. In order to insure the most efficient design of the man-containing capsule, an adequate description of the pilot's body size and workspace envelope is necessary. Such data were obtained during the examination of the Mercury candidates and have been useful to the engineers designing the Mercury capsule.

TABLE 3.2

MEAN HEIGHTS, WEIGHTS, AND AGES
OF AIR FORCE FLYING PERSONNEL, MERCURY CANDIDATES, AND ASTRONAUTS

	Height		Weight		Age	
	Mean	Range	Mean	Range	Mean	Range
Air Force Flying Personnel[3.7]	69.1	59.5-77.6	163.7	104-265	27.9	18-54
Mercury Candidates	68.7	65.7-71.0	162.6	138-190	32.8	27-38
Astronauts	69.1	66.3-70.4	166.5	154-190	34.7	32-38

Much valuable information should be extracted from the body contour maps drawn from the stereophotographs. It would be of considerable interest, for example, to correlate total body surface area of the subjects with their heat tolerances, and the cross-sectional form of the thoracic cavity with g-tolerances, vibration studies, and altitude chamber tests. From contour maps of the Astronauts, furthermore, fabricators of protective garments could make a suit that would fit as a second skin.

The collection of the metrical data and photographic records of the subjects has been significant. These data enable interested personnel to handle individual equipment and workspace problems, foreseen or unforeseen, without requiring the presence of the subject (assuming no significant change in weight).

SUMMARY AND CONCLUSIONS

A sophisticated anthropometric record of each Project Mercury candidate has been obtained. Some of these data have already been applied toward the design of the life-support capsule and the Astronaut personnel equipment. Estimates of the lean-body weight by the Behnke formula agree very well, in general, with independent estimates of the same factor by the radioactive K^{40} method. No attempt was made to rank or rate these men in terms of anthropological measures. The function has been to describe the sample. It could assign such rating only after careful studies of the correlations between anthropological measures and the various aspects of each person's performance.

This body of data is unique. There has been no other study in which such a diverse mass of clinical, physiological, psychological, and anthropological data has been collected on the same sample. The present data, with future extensions, may provide the basis for a long-term study of the interrelationships of these disciplines. Although studies of present data are underway in a limited fashion, they can become more meaningful when a larger sampling is available. At that time, an illuminating contribution to the relationship of man's physical constitution and physiological performance must result.

REFERENCES

3.1. Hertzberg, H.T.E., C.W. Dupertuis, and I. Emanuel. Stereophotogrammetry as an Anthropometric Tool. WADC TR 58-67. Wright Air Development Center, Wright Patterson Air Force Base, Ohio. 1958.

3.2. Behnke, A.R., and W.E. Siri. The Estimation of Lean Body Weight from Anthropometric and X-Ray Measurements. Research and Development TR USNRDL-TR-203, NS 080-001. U.S. Naval Radiological Defense Laboratory, San Francisco 24, California. 1957.

3.3. Behnke, A.R. Military Aspects of Underweight and Overweight. Research and Development Report USNRDL-TR-205, NS 080-001. U. S. Naval Radiological Defense Laboratory, San Francisco 24, California. 1957.

3.4. Sheldon, W.H., S.S. Stevens, and W.B. Tucker. The Varieties of Human Physique. Harper, New York. 1940.

3.5. Dupertuis, C.W., and I. Emanuel. A Statistical Comparison of the Body Typing Methods of Hooton and Sheldon. WADC TR 56-366. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. 1956.

3.6. Damon, Albert. "Physique and Success in Military Flying." Am. J. Physical Anthropology. 13: 217-252. 1955.

3.7. Hertzberg, H.T.E., G.S. Daniels, and E. Churchill. Anthropometry of Flying Personnel - 1950. WADC TR 52-321. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. 1954.

CHAPTER IV

BIOLOGICAL ACOUSTICAL TESTS

PART 1. INTELLIGIBILITY MEASURE

D. J. Baker
R. G. Hansen, Capt., USAF, MC

BACKGROUND DATA

The standard method of specifying a communication system in a point-to-point transmission network is to examine the various components that make up the system. Commonly, there are four major categories or components:

1. The speaker

2. The listener

3. The electronic system

4. The environment in which the first three operate

The demand of continuous investigations in the area of intelligibility measurement can be well documented by the increasing demands placed on the components of this system. These new demands can best be categorized into factors that have a tendency to reduce the probability of message reception, including:

1. Unusual environments, especially higher noise levels than before anticipated

2. Distance requirements associated with such problems as atmospheric radio interference

3. Additional stress on the human operator

In situations where there are requirements for verbal transmission of information, the best components available are desirable. This is especially true of the human operator in present and future operational aircraft. The increased speed of the manned vehicle places a premium on adequate intelligibility.

PROCEDURE

The present study was initiated to determine the relative intelligibility of a panel of experienced pilots and to make recommendations as to the ratings of these individuals and their relative ranks. The basic method was a standardized procedure to estimate relative intelligibility of speakers, listeners, and/or systems. This is essentially the use of standard wordlists representative of everyday language and balanced in frequency of occurrence of sounds to negate the effect of learning a particular set of words. For this study the Harvard PB (phonetically balanced) wordlists were chosen. There are four basic lists and each list may be presented at random. The plan called for each individual to speak each of 50 words comprising a particular wordlist. The carrier phrase "The word is..." was used as a means of maintaining a constant intensity level at the tape recorder. The resulting recordings were played to a panel of trained listeners, the number of listeners varying from 2 to 11 during the 6 weeks of panel listening. The instructions given to the listeners were to write down the words they heard. A -5 db speech-to-noise (s/n) ratio was selected for the presentation of the stimulus materials with the average level of speech presented at 60 db, a reference sound level of 0.0002 dyne/cm.^{2} The -5 db s/n ratio was used because there is less adaptation to the noise at the less favorable s/n ratios. The rationale for presenting the speech at 60 db stemmed from reported works involving PB wordlists in which it was noted that under a "no noise condition" this was the approximate minimum level at which to achieve 96% to 100% intelligibility for the lists. The resulting intelligibility of the combined speech level and s/n ratio was estimated to be approximately 10% to 15% for an average trained speaker. Although this would reduce the average score, it was felt that the results would be more discrete and meaningful in the final analysis. A constant of 33% was added to the resulting score obtained from the average number of correct words from the listener panel in order to depict the average speaker intelligibility score as approximately 50%.

The tabulation of the final data (see table 4.1) verified the rationale of this procedure in which it will be noted that the average for the 31 subjects was 52%. Also shown in table 4.1 is a rating of each pilot on a 1 to 9 scale and the over-all ranks of the pilots. On the basis of the ranking method utilized, 8 of the 31 subjects were above average in intelligibility, 15 were average, and 8 were below average.

The intelligibility of speech under vibration was also investigated. Vertical vibration at frequencies of 7 and 11 c.p.s. at a constant amplitude of 1/4 inch was used. Tape recordings under these two conditions were obtained with the pilot repeating a sentence representative of normal connected discourse.* These recordings were played at random to a panel of listeners with instructions to rank the speech of each pilot on a 1 to 7 basis with 1 being very good and 7 very bad.

The median score of 8 listeners responding to the standard sentence at 2 frequences, 7 and 11 c.p.s., for each pilot was used as the criterion measure. The results are shown in table 4.2. As noted in the table, recordings for subjects J, R, N, and W were not obtained. Also included in the table is the rank in total for both the 7 c.p.s. and 11 c.p.s. vibration conditions. The correlation of rank between the two conditions was statistically significant at the 1% level of confidence. The nonparametric statistic, Wilcoxon Matched Pairs, was used to evaluate the data. The results indicate a statistically significant difference between the two scores for each subject. The 11 c.p.s. appear to affect intelligibility more than 7 c.p.s. The distribution of these scores is shown in figure 4.1.

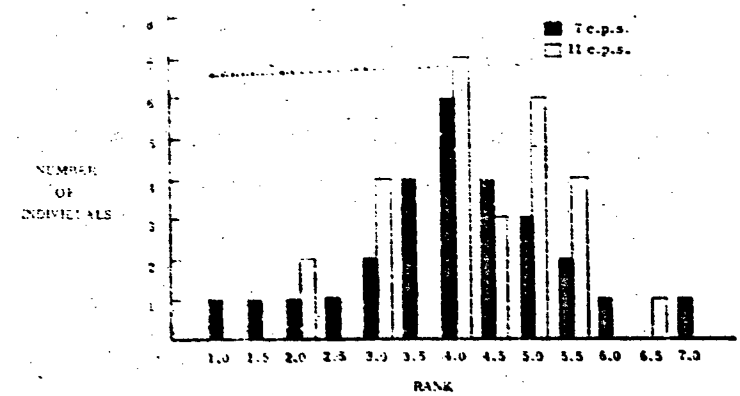


Figure 4.1. Comparison of Speaker Intelligibility under Two Conditions of Vibration (7 and 11 c.p.s.) as Judged by Listeners Using a 1 to 7 Rating Scale.

---

* "Tomorrow evening at this hour, the famous physician, Dr. J. O. Lee, will speak to you on a topic of vital importance."

TABLE 4.1

RELATIVE INTELLIGIBILITY SCORES OF 31 SPEAKERS WITH THE RESPECTIVE RANKINGS AND THE RELATIVE RANKS IN TOTAL

Subject	Score Percent Intelligibility	Rating Scale 1 to 9	Rank in Total
A	56	5	10
B	55	5	12.5
C	59	6	6
D	53	5	17.5
E	40	3	26
F	53	5	17.5
G	49	5	21
H	58	6	7
I	52	5	19.5
J	61	6	5
K	45	4	24.5
L	54	5	15
M	56	5	10
N	45	4	24.5
O	63	6	4
P	39	3	27.5
Q	48	5	22.5
R	66	7	3
S	54	5	15
T	54	5	15
U	39	3	27.5
V	48	5	22.5
W	67	8	1.5
X	36	1	31
Y	67	8	1.5
Z	37	2	30
AA	56	5	10
BB	55	5	12.5
CC	52	5	19.5
DD	38	3	29
EE	57	6	8

In an effort to determine whether the score for either the 7 c.p.s. or 11 c.p.s. vibrations condition showed any relationship to the rank of the speakers on the intelligibility section of the program, the scores under each of the two vibration conditions were ranked and the Spearman Rho was used to correlate the resulting rank with the rank from the word intelligibility program. In neither case was there a statistically significant relationship between the two scores. It would thus appear that, under the condition of vibration, the listeners use an entirely different set of concepts in rating the individual than they use under the word intelligibility program. The factor of individual differences as to the effect of vibration is also indicated. The vibration appears to partially confound the basic intelligibility score. The resulting tremor in the voice has a deteriorating effect that shows no direct relationship to the word intelligibility score.

TABLE 4.2

MEDIAN SCORES FOR SPEAKERS UNDER TWO VIBRATION CONDITIONS AS JUDGED BY LISTENERS UTILIZING A 1 TO 7 RATING SCALE

Subject	7 c.p.s.	11 c.p.s.
A	2.0	5.0
B	5.5	4.0
C	3.0	3.0
D	3.0	4.0
E	4.0	5.0
F	2.5	3.0
G	3.5	4.5
H	5.0	5.0
I	4.5	3.0
J	None	None
K	1.5	2.0
L	4.0	4.0
M	4.5	4.5
N	None	None
O	5.5	6.0
P	5.0	5.0
Q	4.0	4.0
R	None	None
S	7.0	5.0
T	3.5	6.0
U	3.5	4.5
V	4.0	3.0
W	None	None
X	6.0	6.0
Y	4.5	6.0
Z	3.5	4.0
AA	4.5	4.0
BB	4.0	5.0
CC	4.0	4.0
DD	5.0	6.5
EE	1.0	2.0

SUMMARY

Word intelligibility scores from 31 speakers were obtained. On the basis of a 1 to 9 scale the speakers' scores were ranked. Eight of the 31 subjects were above average, 15 were average, and 8 were below average. Utilizing a rating of 1 to 7, listeners evaluated the effect of vibration upon the intelligibility of connected discourse. There was a statistically significant positive correlation between the two conditions of vibration (1% level of confidence). However, there was a statistically significant difference in the ratings with the 11 c.p.s. vibration condition having a more deteriorating effect on intelligibility.

PART 2. EFFECT OF NOISE ON THE ABILITY TO PERFORM ADDITION

J. E. Steele, Maj., USAF, MC

INTRODUCTION

Noise is capable of interfering with effective human activity. As sound increases to intensities thousands of times greater than those encountered in ordinary experience, it produces potentially serious distracting stimuli. The present test was designed to measure the effects of high noise levels on the performance of a simple mental task.

TECHNIQUE

The intense noise (145 db) was produced by a locally designed broadband siren. The subject's ears were protected by muff-type protectors, Willson Sound Barrier No. 258. Each subject was tested individually in a small, reverberant room (figure 4.2). He was allowed 3 minutes to perform a number of serial additions. This was done first in quiet, then in noise, and again in quiet. Equivalent lists of addition problems were used. The following are examples of the addition problems used:

<u>35</u> 8 4 6 5 3 7 2/ 4 5 3 6 9

<u>30</u> 6 8 4 7 5/ 9 3 6 8 1 5 7

The subject was required to add a row of figures until the sum equalled the underlined 2-digit number. He placed a slash-line following the last digit needed to form the sum.

SCORING

The performance score (S) was equal to twice the number of additions completed during noise (N) minus the number completed during the two quiet periods (Q_1 and Q_2) plus 3. Three was added to all scores in order to center the distribution in the 0 to 9 range as required by the recording methods. Scores outside this range were recorded as 0 or 9. Thus, the formula used was:

$$S = 2N - (Q_1 + Q_2) + 3$$

RESULTS

A small control group of college students showed a slight average deterioration in performance in noise while the candidates showed an average increase in rate of performance. Errors in addition were much more common among the college students. The total number of errors for the candidates was 22 (about 1% of the problems worked). Seven of these errors occurred during the first quiet period, 5 during the noise, and 10 in the final period of quiet. They were ignored in the scoring because of their small number and apparently random occurrence.

The noise produced an average change in rate of addition which is approximately two fifths as great as the average difference in rate existing between the different subjects when adding in the quiet. The reliability of the test for measuring individual susceptibility to noise-induced changes in performance is not known but is believed to be low. A score of 4 indicates no effect of noise on rate of addition. A higher score shows improved performance during noise. One fourth of the candidates showed a reduced rate of performance in the noise. The extreme was a 15% reduction. The maximum increase was 26% and the median 5%.

Noise at the levels used (145 db broadband) is physically harmless (except to unprotected ears). It has no direct effect on any common activity except to interfere with hearing. It does subject the body to a background of noticeable stimulation of a tactile nature due to the vibration of the body surfaces. This vibration may irritate the trachea sufficiently to produce mild coughing. Somewhat unpleasant resonances occur if the mouth is opened slightly or if the teeth rest together lightly. Sinus discomfort due to the vibration has been noted by individuals having some pre-existing sinus inflammation.

The effect such stimulation produces on an individual depends on his past experiences with noise in general and with similar noises in particular. Rapid adaptation is usual. Any activity required of the individual also affects his reaction to the noise, and individual variations show up. The purpose of this test was to discover such individual differences. The noise, being a diffuse stimulus, can tend to arouse a subject increasing his alertness. This is the type of effect which causes interference with sleep. The same arousal may distract a subject's attention from the performance of an assigned task. Paradoxically, when the noise has become familiar, it is relatively monotonous and may serve to shield a subject from more meaningful stimuli which might distract him. Subjects not assigned a task frequently appear drowsy or sleepy.

The effects observed in the present tests were not considered serious and were given little weight in the final recommendations.

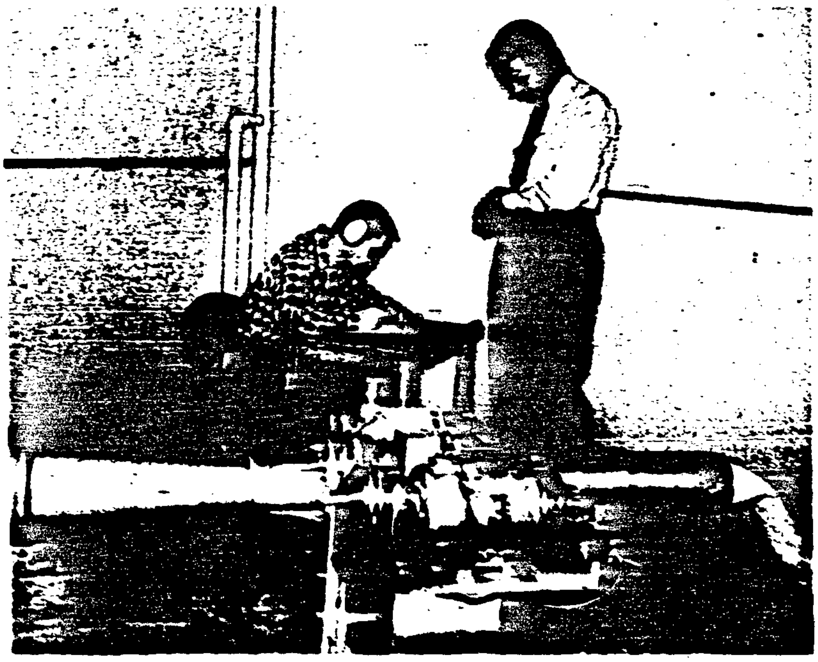


Figure 4.2. Sound Generator. Cloth Hose Conveys High-Pressure Air to Siren. Subject and Tester Wear Ear Defenders.

PART 3. THE INFLUENCE OF VIBRATION ON HOLDING THE HORIZONTAL POSITION UTILIZING THE EQUILIBRIUM CHAIR

R. R. Coermann, Ph. D.
E. B. Magid, Capt., USAF, MC
Walter Wolff

INTRODUCTION

High-performance aircraft and space vehicles, particularly during the period of re-entry, may encounter low-frequency, high-amplitude vibrations. The ability of man to perform in such an environment for any length of time may be of vital importance. The ability of a subject to maintain the horizontal position during low-frequency vibrations while counteracting pitch-and-roll disturbances was tested. The subject was blindfolded so that the modalities of equilibrium, other than vision, could be studied.

Changes in performance during vibration (when compared with static tests) are dependent upon physiological and psychological variables. Without vision, two main integrated systems function to maintain equilibrium. The labyrinth, an organ of special sense, detects the position of the head in space and the relationship of the head to the neck. The other system consists of a complex of nerve receptors distributed throughout the body. They have the general function of receiving various kinds of physical and chemical stimuli. Vibration affects only those receptors sensitive to displacement. They have been named "kineceptors" (Greek, kine - kinetikos, of motion) and include the receptors of touch, pressure, proprioception, and visceral sense. Pain receptors stimulated by stretching fall within this group. Organ displacement may be so great that not only visceral movements are perceived, but also the pain receptors are stimulated.

TEST TECHNIQUE

A chair has been constructed which can be moved in the direction of pitch and roll by two hydraulic cylinders (figure 4.3). These cylinders are driven by electrohydraulic valves connected to an electrical circuit in which the output of an ultralow frequency generator is fed. Motions of the chair produced by this random generator can be compensated for by a control stick installed on the chair. The blindfolded pilot was strapped in the chair with a lap belt and shoulder straps. It was his task to compensate for all motions produced by the random noise generator by using the control stick and to hold the chair as closely as possible to what he considered his horizontal level. The entire chair was installed on a shake table, shaking with a constant amplitude of 1/4-inch double amplitude in the frequency range of 0 to 15 c.p.s. (see figure 4.3). An oscillograph simultaneously recorded the deviation of the position of the horizontal level and the output of the random noise generator.

TEST PERFORMANCE

The pilot received a 10-minute period of exercise without the blindfold and then a 10-minute period with the blindfold, both with and without vibrations. A short test with vibrations introduced the vibratory stress to the subject. The test profile consisted of 6 tests, each of 1-minute duration. The vibrations were in the frequencies of 3, 5, 7, 9, 11, and 15 c.p.s. Before and between each run a record of 1 minute without vibration was taken.

The pulse rate, respiration rate, and blood pressure were taken at the beginning of each test, immediately before the first and immediately after the last run with vibrations. After each run the pilot was asked to remark on the various sensations he experienced.

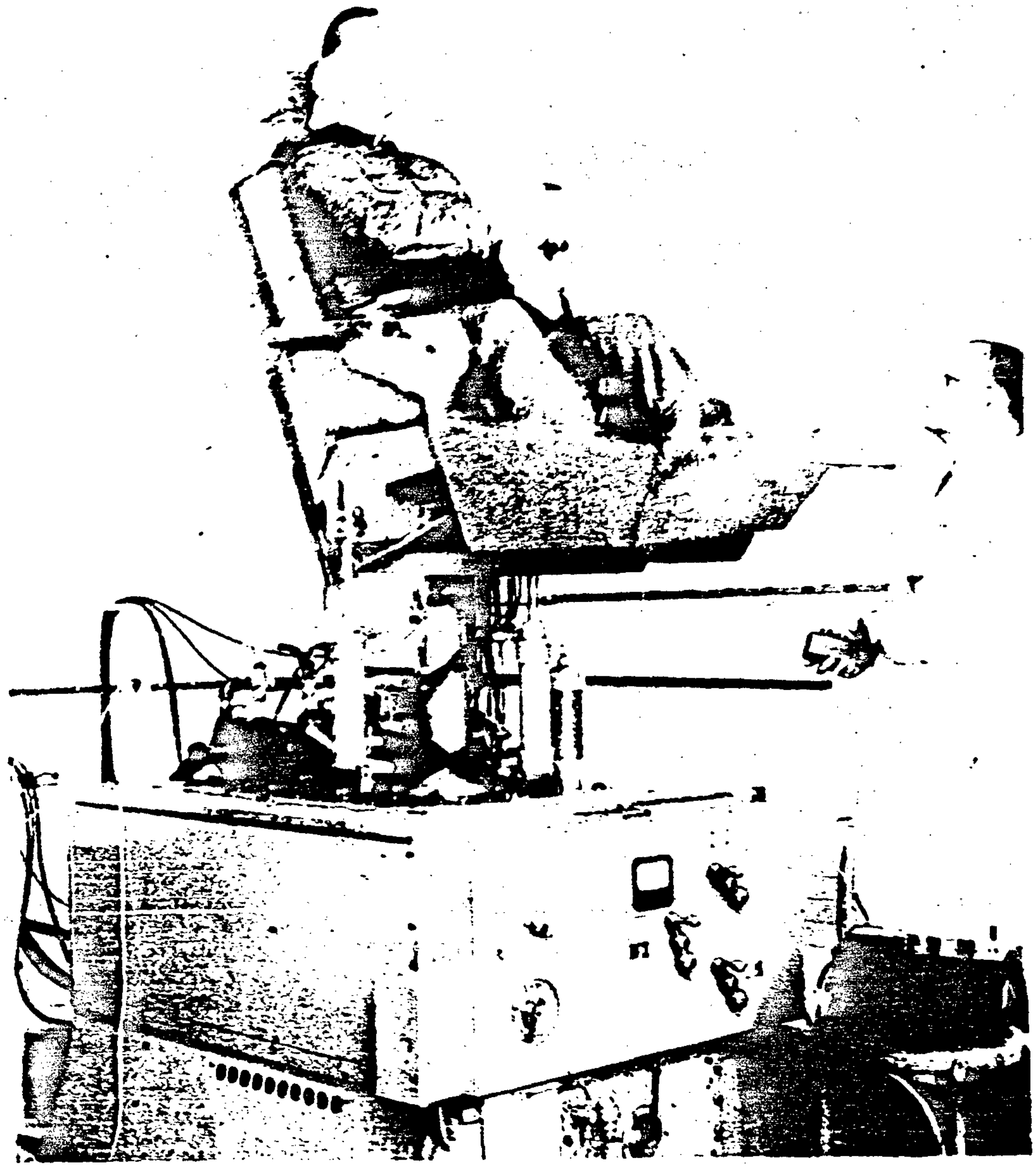


Figure 4.3. Equilibrium-Vibration Chair. Subject Holds Control Stick. Medical Monitor Holds On-Off Control Box.

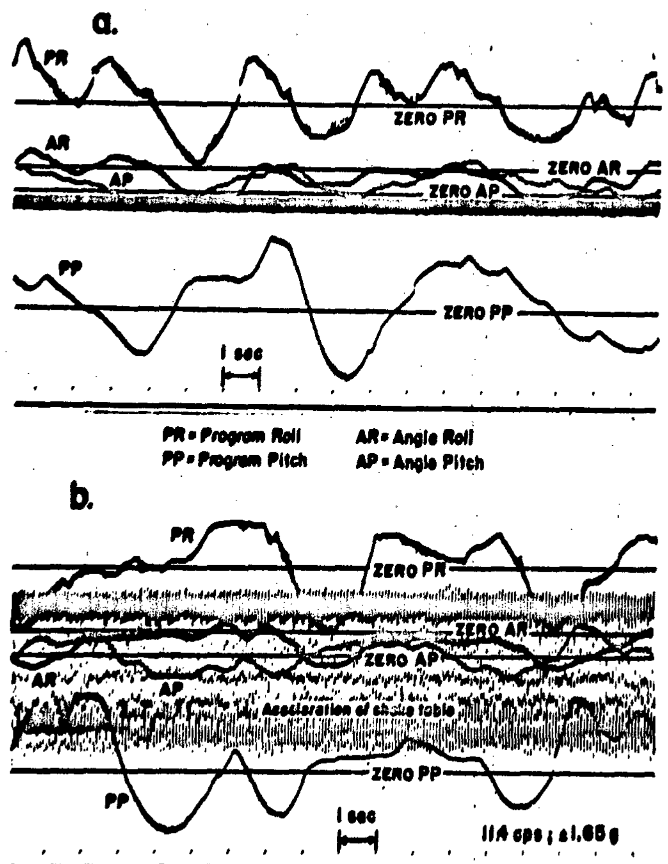


Figure 4.4. Typical Examples of Oscillograms Showing Excellent Response

A. Before Vibration: Subject shows excellent compensation to variations in pitch and roll.

B. During Vibration: Subject shows little deviation in performance during a stressful vibration as compared to his performance with no vibration.

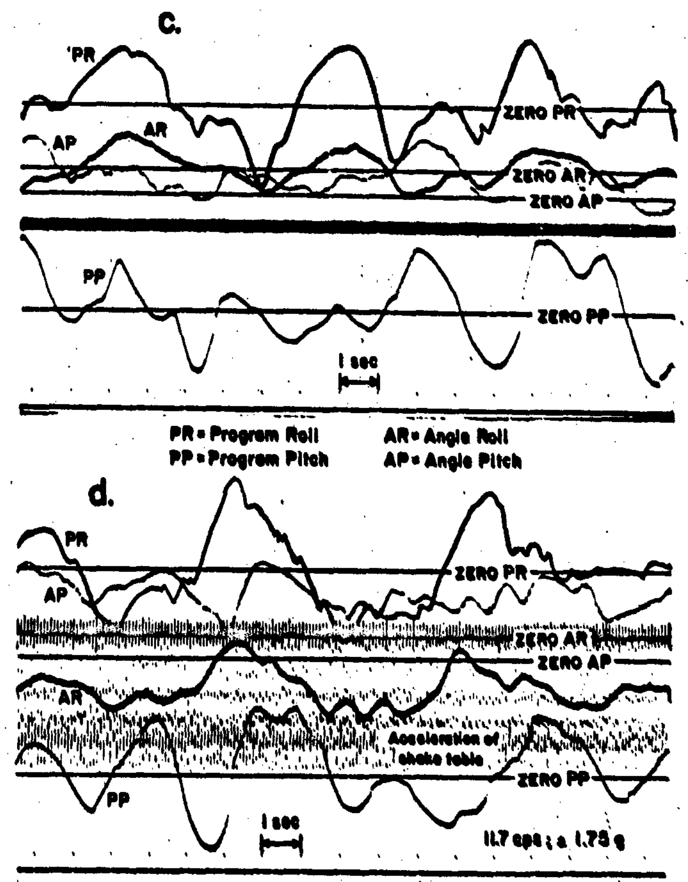


Figure 4.5. Typical Examples of Oscillograms Showing Poor Response

C. Before Vibration: Subject shows some difficulty in maintaining the horizontal position without vibration.

D. During Vibration: Subject shows extreme difficulty in maintaining the horizontal position during a stressful vibration.

EVALUATION OF THE OSCILLOGRAMS

The following six traces are recorded on the oscillograms (see figures 4.4 and 4.5):

1. Angle of the seat in roll (AR)
2. Program voltage to the roll control valve (PR)
3. Acceleration of the shake table (Vibration)
4. Angle of the seat in pitch (AP)
5. Program voltage to the pitch control valve (PP)
6. One-second time marks

The zero lines for the angles of pitch and roll were determined by placing the seat in the horizontal position. The zero lines for the pitch and roll voltages were taken at zero voltage input. The accelerometer was calibrated statically.

In the evaluation of a subject's performance, the area above and below the zero line of each record was integrated by a planimeter giving the factors:

1. AR = Angle in roll: subject's deviation from his horizontal position in roll during vibration
2. PR = Program in roll
3. AP = Angle in pitch: subject's deviation from his horizontal position in pitch during vibration
4. PP = Program in pitch

The ratios $\frac{AR}{PR}$ and $\frac{AP}{PP}$ were calculated for each record. The frequency of vibration and acceleration of the shake table were determined by the acceleration tracing and the time marks. The analysis of the curves gave 13 values for the quotient $\frac{AR}{PR}$ and 13 values for the quotient $\frac{AP}{PP}$. Seven of these values of each group were taken without vibration ($\frac{AR}{PR}$ O and $\frac{AP}{PP}$ O) and six with vibration ($\frac{AR}{PR}$ V and $\frac{AP}{PP}$ V). Two seemingly appropriate methods could be used to calculate the final score (F) from the above values (see table 4.3):

1. The deviation of each $\frac{AR}{PR}$ V and $\frac{AP}{PP}$ V from the previous $\frac{AR}{PR}$ O and $\frac{AP}{PP}$ O was calculated. The average deviations were expressed as numbers for roll (R) and pitch (P). The final score (F) was calculated from $F = \frac{R + P}{2}$. Using this method every performance was related to the preceding performance without vibration. Thus, the skill of the subject to operate the equipment was compared with his performance only. The subject could choose his own mean horizontal position after every vibration. This was important because the $\frac{AR}{PR}$ and $\frac{AP}{PP}$ values depend not only upon variations of position but also upon the mean position of the seat during the measuring period. It was not the purpose of this test to investigate the ability of the subject to operate the equilibrium seat and to hold a given position. The purpose was to check the effect of vibration upon his ability to hold what he considered the horizontal level. This method has the disadvantage of omitting any residual effect just preceding the vibratory stress. However, the results showed that many of the subjects presented remarkable changes of the $\frac{AR}{PR}$ O and $\frac{AP}{PP}$ O values after the test runs, indicating that even after 1 minute of recovery the subject was still quite disturbed.

TABLE 4.3

A RATING OF THE RESULTS

BASED UPON A 1 (POOREST) TO 9 (EXCELLENT) CLASSIFICATION

	Method 1		Method 2	
Group	Mean Deviation from the Horizontal Position During Vibration	Rank	Mean Deviation from the Horizontal Position During Vibration	Rank
	0.000-0.150	9	0.000-0.100	9
I	0.151-0.230	8	0.101-0.160	8
	0.231-0.300	7	0.161-0.190	7
	0.301-0.370	6	0.191-0.250	6
II	0.371-0.430	5	0.251-0.300	5
	0.431-0.500	4	0.301-0.350	4
	0.501-0.570	3	0.351-0.400	3
III	0.571-0.700	2	0.401-0.500	2
	0.700	1	0.500	1

2. The average of all $\frac{AR}{PR}$ O and $\frac{AP}{PP}$ O values were calculated. Then the average of the deviations of this value were calculated:

$$\frac{\overline{AR}}{PR}\,O = \frac{\frac{AR}{PR}\,O}{7} \qquad \frac{\overline{AP}}{PP}\,O = \frac{\frac{AP}{PP}\,O}{7}$$

$$\frac{\overline{AR}}{PR}\,O = \frac{\frac{AR}{PR}\,O}{7} \qquad \frac{\overline{AP}}{PP}\,O = \frac{\frac{AP}{PP}\,O}{7}$$

$\overline{AP}$ = Mean angle of pitch

$\overline{AR}$ = Mean angle of roll

= Change

= Sum

O = Relative to test with no vibration

Relate the average of the $\frac{AR}{PR}$ V and $\frac{AP}{PP}$ V values to the $\frac{AR}{PR}$ O and $\frac{AP}{PP}$ O values to obtain the final score. This method eliminates the skill of the subject to operate the equilibrium chair, and it also takes the residual effect of vibration into consideration.

RESULTS

Subjective responses to the low-frequency vibration tests are shown in table 4.4. At 7 and 9 c.p.s., 11 of the subjects experienced chest pain substernally or over the precordium, but had no pain of the left upper extremity as is experienced with myocardial ischemia. All sensations of pain, whether in the chest or abdomen, were usually described as mild to moderate in intensity, of slow onset, and increasing with crescendolike characteristics. Six of the subjects experienced either moderate pain of the abdomen, paraumbilical in location, or a feeling of tenseness in this region. Only one of these subjects fell within the group considered excellent. At 11 and 14 c.p.s., 16 of the subjects experienced a moderate to exquisite urge to urinate and/or defecate.

Seven subjects felt that the vibrations seemed to completely mask the sense of equilibrium, particularly at the frequencies above 7 c.p.s. These subjects generally fell within the poorer group. Three subjects experienced sweating and stated that they felt very warm and uncomfortable. They appeared to be the most apprehensive, and two of them had the lowest ranking scores.

Three of the pilots, when blindfolded, turned their heads laterally approximately 15° to 20° toward either side. When questioned they gave histories of moderate to severe otitis-media or mastoiditis occurring during their childhood. The head was turned toward the side of the affected ear. Interestingly though, they performed better than half the group. None of the group experienced vertigo or air sickness.

One member of the group did not finish the test because he developed severe pain of the left upper quadrant. He gave a history of malaria with splenomegaly which occurred approximately 10 years before. Upon examination, the subject did not present splenomegaly or hepatomegaly. Tenderness of moderate intensity was present at the area of the spleen.

Pulse rate, blood pressure, and respiratory rate showed only slight changes after the runs. Ranking of the subjects in accordance with their final scores is shown in table 4.5.

DISCUSSION AND CONCLUSIONS

The results suggest that the labyrinth is little affected by vibrations under the described experimental conditions. As the frequency of vibration increased, the movements of the chair became more masked by the vibrations due to the tremendous increase in kineceptor stimulation and, together with the stressful conditions of pain and extreme discomfort, the pilot's ability to perceive the horizontal plane became severely challenged.

Performance in this study was affected by mechanical alternating forces acting directly on the head and extremities, and increased muscle tonus due to the alternating stretching of tendons and ligaments of the skeletal musculature. At certain frequencies pain of the chest or abdomen may be encountered and at other frequencies the urge to urinate or defecate may be experienced. Vibration, encountered during this study, then presents the body with a multifaceted stress, testing not only the physiological status but also psychological processes. As frequency increased, the subject experienced extreme discomfort, pain, and bladder and sigmoid colon urgencies. With rapid, severe, alternating forces acting upon various body parts, associated with increase in work output, motivation becomes a prime factor in determining performance of equilibrium. It then follows that these experiments cannot be assured to represent a clear-cut test of the influence of vibration on the sense of equilibrium, per se, but rather must be taken as the individual's total response to vibrational stress and the decrement of performance under these conditions. Only future research can estimate the validity of this test for the selection of specific qualification.

TABLE 4.4

SUBJFCTIVE RESPONSES TO VIBRATION TESTS

Subject	I	II	III	IV	V	VI
A				S		
B						
C		Sl			Sl	Sl
D		Sl		M	M	
E	M				M	
F				S		Sl
G		M		M		
H						
I	M	Sl		M		
J	S					
K						
L				Sl		
M				Sl	Sl	
N					I	
O		M	M			
P						
Q		M			Sl	M
R	S		M			
S						
T				M		Sl
U						
V				M		
W						
X		M	Sl	Sl	Sl	Sl
Y				Sl	Sl	
Z				S	Sl	
AA				M		
BB				M		Sl
CC					Sl	
DD				Sl	Sl	
EE				S		

I - General Discomfort
II - Loss of Sense of Equilibrium
III - Warm with Diaphoresis
IV - Urge to Urinate and/or Defecate
V - Pain in Chest
VI - Discomfort and/or Muscle Tenseness in the Abdomen

Sl - Slight
M - Moderate
S - Severe
I - Intolerable

TABLE 4.5

PERFORMANCE DATA ON VIBRATION TESTS

	Method 1		Method 2	
Subject	Final Score	Rank	Final Score	Rank
A	0.246	7	0.186	7
B	0.214	8	0.152	8
C	0.273	7	0.232	6
D	0.407	5	0.264	5
E	0.975	1	0.517	1
F	0.243	7	0.195	6
G	0.330	6	0.195	6
H	0.157	8	0.121	8
I	0.671	2	0.375	3
J	0.148	9	0.075	9
K	0.355	6	0.313	4
L	0.352	6	0.371	3
M	0.554	3	0.350	4
N	0.449	4	0.264	5
O	0.723	1	0.621	1
P	0.310	6	0.263	5
Q	0.227	8	0.198	6
R	0.646	2	0.544	1
S	0.369	6	0.249	6
T	0.393	5	0.292	5
U	0.241	7	0.181	7
V	0.291	7	0.196	6
W	0.482	4	0.339	4
X	0.352	6	0.228	6
Y	0.417	5	0.160	8
Z	0.561	3	0.302	4
AA	0.726	1	0.499	2
BB	0.317	6	0.180	7
CC	0.354	6	0.362	3
DD	0.396	5	0.288	5
EE	0.223	8	0.176	7

CHAPTER V

HEAT TESTS

J. Gold, Capt., USAF, MC

INTRODUCTION

High-performance aircraft and space vehicles are expected to heat to sustained high temperatures, especially during the period of re-entry. It is therefore necessary to see how man is equipped to withstand heat, and if some men can withstand it better than others.

What effects do progressive heat loads have on humans? The one that is of chief concern is that, with the absorption of more and more heat, the body will gradually be thrown into the clinical state known as heat stroke, a condition in which there is a very high mortality. It is characterized by coma or extreme stupor, cessation of sweating, hot, dry, red skin, high rectal temperature (usually over 105° F.), and high skin temperatures. The heat-dissipating mechanisms of the body are unable to keep pace with the absorption of calories from the outside, so that gradually the body absorbs more than it can handle, and incipient heat stroke develops.

The cessation of sweating is an indispensable condition to the development of heat stroke. It follows that sweating is the chief mechanism for dissipating heat. However, the process of sweating is dependent on many factors—the primary hypothalamic heat-dissipating center, the cardiovascular system, the sweat glands, relative hydration, neural endowment, acclimatization, and many others. There are many measurements which can be made that give a picture of the sum total of these heat-dissipating mechanisms so that, by providing controlled heat exposures and taking the proper measurements, it is possible to distinguish poor heat subjects from good ones.

PROCEDURE

Environment and Length of Exposure:

Each subject was exposed to an ambient temperature of 130° F. with a relative humidity of 8% and an air motion of 3 to 5 m.p.h. (see figure 5.1).

Clothing:

Clothing consisted of one set of thermistor underwear (long cotton underwear covering all four limbs), one K-2B flying suit (a light-permeable suit), one pair of cotton socks, and one pair of leather shoes. Total clothing is equal to approximately one clo insulation.

Other Measurements and Examinations:

1. Nude weight starting and at termination yielded a total sweat loss (total weight loss) accurate to ±10 grams.

2. Clothed weight starting and at finish yielded data for calculating the evaporative loss and, together with 1., the ratio of evaporative loss over total weight loss (E/S ratio).

3. Heart rate was recorded simultaneously on EKG on a cathode-ray oscilloscope and on paper.

[illegible] Are Attached [illegible] Are [illegible] Extremities

4. Blood pressure and EKG readings were taken continuously.

5. Subject was given auscultatory heart examination before and after heat exposures.

Three calculations were made by which subjects were evaluated for their capability to withstand heat:

1. Body Heat Storage.—Body heat storage is a measure, in terms of calories per square meter of body surface per hour, of the heat which a body will store when exposed to a hot environment. The equipment used to measure body heat storage is principally the set of thermistor underwear. Multiple skin thermistors which record skin temperatures from all parts of the body are located in this long cotton underwear. In addition, attached to this suit is a soft malleable rod, with a thermocouple at the end. This is inserted into the rectum to a depth of about 10 cm. and thus acts as a rectal thermocouple from which deep body temperatures are read. The temperature-sensing devices feed into a Brown potentiometer which automatically and continuously records in sequential fashion the temperature readings from each thermistor and/or thermocouple. These readings, taken every 15 minutes, are then transferred onto a printed form from which body heat storage is calculated (see figure 5.2).

Body heat storage is probably the most reliable parameter for evaluating the performance of a subject under heat stress. The better his heat dissipation is, the lower will be his net absorbed calories.

2. Modified Craig Index of Strain.—The Modified Craig Index of Strain consists of three factors: a. terminal heart rate divided by 100, b. sweat rate in terms of kilograms per hour, and c. rectal rise rate in terms of degrees centigrade per hour. These three factors are simply added together to yield a sum, which is the index. And obviously, as the subject incurs more strain, the index becomes higher.

3. A New Heart Index.—A new correlative index based on heart rate* has been developed and expresses a theoretical relationship—a ratio between "theoretical heat absorbed" and actual heat absorbed. The higher the index, the greater is the strain. The index correlates highly with body heat storage.

SCORING

The entire group of 31 candidates was used as its own control. The data were evaluated statistically and each candidate was assigned a score in each of the three parameters: body heat storage, Modified Craig Index of Strain, and the new heart index. The three scores which each subject accrued were weighed equally, added, and an average was obtained. The relative ranking and rating of all candidates were based on this average.

RESULTS

The results of this ranking are tabulated in tables 5.1 and 5.2. Assigned statistical scores are indicated for each of the three parameters used. Table 5.2 shows the rank and rating of each candidate. The best possible score was 9.0; the worst, 0.0. The bulk of the scores ranged between 3.0 and 6.0. Those who made above 6.0 were considered relatively superior, while those who scored below 3.0 were considered poor.

---

* Further details of this index, developed by Capt. Joseph Gold, USAF, MC, of the Aerospace Medical Laboratory, will soon be published in a WADC technical report and in the Journal of Applied Physiology.

BODY HEAT STORAGE CHART

Area	Coefficient	No.	Location	Control Temperatures 0	5	10	Temperatures in All-Weather Room 0	15	30	45	60	75	90	105	120
Head	0.074	1-1	Head		95.9	96.5		100.2	99.0	97.7	97.9	97.8	99.1	99.2	98.6
		2-1	Neck		95.3	95.5		99.4	98.8	98.7	98.8	99.0	99.2	99.5	94.2
Trunk	0.238	3-1	Scapula		96.3	96.8		99.5	99.6	99.6	100.0	100.3	100.3	100.1	100.5
		4-1	Kidney		95.0	95.5		99.6	99.7	99.7	100.0	100.0	99.9	100.0	100.3
		5-1	Nipple		95.7	96.2		98.8	99.3	99.3	99.0	98.8	99.0	99.6	99.6
		6-1	Abdomen		96.4	96.8		98.8	99.1	99.3	99.3	98.5	99.9	100.0	100.1
		7-1	Manifold		94.7	94.8		98.8	99.5	98.7	99.3	98.7	99.8	100.0	100.3
Arms	0.130	8-1	Upper Arm, Right		95.7	96.0		98.8	99.0	99.3	99.2	99.1	99.3	99.5	99.7
		9-1	Lower Arm, Left		93.8	93.7		97.8	98.5	98.5	98.3	98.3	98.4	98.3	98.8
Hand	0.050	10-1	Hand, Manifold		91.8	93.1		100.0	100.2	104.2	102.6	100.5	101.0	101.0	102.0
		11-1	Hand, Single												
Legs	0.438	12-1	Upper Ant. Leg, Right		94.2	94.5		98.3	98.8	99.0	99.2	99.3	99.2	99.5	99.7
		1-2	Upper Post. Leg, Left		94.4	95.2		99.5	99.7	99.7	99.6	99.8	99.3	100.2	100.2
		2-2	Lower Ant. Leg, Right		93.4	93.5		96.1	97.5	98.2	98.9	99.2	99.1	99.2	99.2
		3-2	Lower Post. Leg, Left		95.8	95.6		98.5	99.2	99.3	99.3	99.3	99.2	99.3	99.6
Feet	0.051	4-2	Foot, Manifold		91.1	91.0		98.6	100.3	100.5	100.8	100.7	101.3	101.2	101.5
		5-2	Foot, Single		80.3	86.2		98.7	100.1	100.5	100.7	100.9	101.0	101.1	102.3
$q_s = \frac{66.1 \times 0.83 \times 1.28}{1.82}$			Rectal Temperature, °F.		100.3	100.3		100.1	100.1	100.2	100.5	100.6	100.8	101.0	101.2
= 38.6 Cal./m.^{2}			Average Skin Temperature, °F.		94.3	94.8		98.6	99.2	99.4	99.5	99.4	99.5	99.8	99.9
= 19.3 Cal./m.^{2}/hr.			(0.33) Average Skin		31.3	31.3		32.5	32.7	32.8	32.8	32.8	32.8	32.9	33.0
			(0.67) Rectal		67.2	67.2		67.1	67.1	67.1	67.3	67.4	67.5	67.7	67.8
			Average Body Temperature, °F.		98.5	98.5		99.6	99.8	99.9	100.1	100.2	100.3	100.6	100.8

q_s = Body Heat Storage
66.1 = Body Weight in kg.
0.83 = Specific Heat of Body
1.28 = Increase of Average Body Temperature in °C.
1.82 = m.^{2} of Body Surface

Figure 5.2. Sample Body Heat Storage Chart

TABLE 5.1

FINAL SCORE TABULATION OF HEAT TESTS

Subject	Assigned Statistical Score Index of Strain (Modified Craig)	Assigned Statistical Score Body Heat Storage (cal./m.^{2}/hr.)	Assigned Statistical Score Correlative Heart Index (New Index of Strain)
A	7.6	4.1	3.7
B	5.8	4.1	0.2
C	7.9	1.4	6.5
D	4.8	0.0	6.9*
E	5.4	6.2	6.2
F	5.9	3.1	3.2
G	8.6	8.2	9.0
H	7.5	8.4	1.4
I	1.7	9.0	7.7
J	3.2	2.6	4.3*
K	1.3	8.1	6.5
L	4.3	5.8	6.0
M	4.5	2.6	3.2
N	4.4	5.9	5.0
O	1.5	1.5	4.3
P	7.8	8.7	8.4
Q	8.3	7.6	7.7
R	3.1	0.8	3.2
S	1.7	7.9	7.3
T	0.2	3.1	0.8
U	7.7	7.6	4.3
V	5.7	4.5	6.9
W	0.6	4.0	0.1
X	0.5	0.8	0.0
Y	2.3	1.8	4.8
Z	5.5	0.5	6.6
AA	7.5	5.4	4.0
BB	4.8	6.3	3.3
CC	4.2	1.9	6.9
DD	4.9	8.2	5.8
EE	5.2	3.1	4.5

* Estimated

TABLE 5.2

FINAL RANKING OF CANDIDATES ON HEAT TESTS

Rank	Subject	Score
1	G	8.60
2	P	8.30
3	Q	7.87
4	U	6.53
5	DD	6.30
6	I	6.13
7	E	5.93
8	H	5.77
9	V	5.70
10	AA	5.63
11	S	5.63
12	L	5.37
13	K	5.30
14	C	5.27
15	A	5.13
16	N	5.10
17	BB	4.80
18	CC	4.33
19	EE	4.27
20	Z	4.20
21	F	4.07
22	D	3.90
23	M	3.43
24	B	3.37
25	J	3.37
26	Y	2.97
27	O	2.43
28	R	2.37
29	W	1.57
30	T	1.37
31	X	0.47

DISCUSSION

The foregoing selection system yields valid information in general, but represents a framework that can be much improved as new techniques for measuring physiological performance become available. The system is extremely sensitive in picking out those who react very well to heat and, also, those who react very poorly. For the majority which falls in between these two groups, the system must be regarded as less sensitive. Any system of selection, unless actual performance under expected conditions can be incorporated into it, cannot be regarded as a positive one. However, such a system negatively selects—that is, it weeds out those who would be unsuitable for physical or physiological reasons. This fact, combined with the fact that the system can differentiate (but not sharply) the superlative from the average, makes an initially effective selection program.

ADDENDUM

Certain cardiocirculatory changes not reported previously were recorded during this program. They were concerned mainly with EKG and auscultatory findings.

Changes seen in respect to EKG were: 1. inversion of T-wave, 2. disappearance of T-wave, 3. S-T segment depression, 4. occasional unifocal extrasystole, and 5. delayed intrinsicoid deflections.

Changes seen in respect to auscultatory findings were in the development of transient systolic murmurs. These cardiocirculatory changes will be elaborated in a forthcoming paper by Dr. Gold.

CHAPTER VI

PHYSICAL FITNESS TESTS

C. L. Wilson, Capt., USAF, MC

APPROACH TO PROBLEM

Research has been accomplished in the following important areas: cardiopulmonary physiology, pressure breathing, autonomic and central nervous system physiology, physical fitness, physical conditioning, and factors influencing motivation.

This research has extended over a 5-year period and represents the combined experiences of Capt. T.F. McGuire, USAF, MC, Capt. F.J. Leary, USAF, MC, and Capt. C.L. Wilson, USAF MC. Capt. McGuire[6.1,6.2] studied previously developed stress tests and developed new ones. McGuire's reports on this early experience indicated that this test battery would be a valuable starting place for special project crew selection programs.

As described in the Introduction, this particular testing program had candidate recommendation as its main goal. Identifying valuable nonspecific tests was a secondary consideration for this particular project. The coinvestigators, with invaluable assistance from the program coordinator, agreed that certain necessary departures would be made from the physical fitness profile recommended by McGuire. These changes in McGuire's suggested tests with substantiating reasons are described in Appendix II.

Several additional tests were incorporated into the physical fitness test program. These are discussed below:

Treadmill:

A multitude of treadmill tests has been used to study physical fitness, stamina, motivation, physiological responses and reproducibility of test results. Balke[6.3] recommended a treadmill test profile. His work demonstrates enviable reproducibility. This test was adopted because of its ease of administration, reliability, and the availability of previous population performance data. An unintentional, yet irrevocable error (since corrected) committed by the author greatly altered the results of this test. Balke's instructions were to raise the treadmill each minute "to such an angle that the vertical ascent becomes 1% of the belt travel in a given time." The treadmill angle was raised 1% of 90° or 0.9° each minute. This modification is a more severe test, and it was kept constant for all candidates. It is recommended that the Balke technique be pursued in future testing profiles.

Catacholamines Analysis:

This study was recommended by McGuire and was performed with additions.*

* The samples were analyzed by Bio-Science Laboratories as subcontractors through the Lovelace Foundation, Albuquerque, New Mexico.

Serum Corticosteroid Analysis:

Hale et al.[6.4,6.5] demonstrated a significant rise in the hydrocortisone and the corticosteronelike fraction in plasma of B-52 aircrew members. This rise did not represent a diurnal variation, but rather reflected the effect of a prolonged flight. Marchbanks et al.[6.6] noted a similar rise in urinary ketosteroids. The coinvestigators believed it would be valuable to document the variations in plasma corticosteroid rise during MC-1 tests.*

DISCUSSION OF THE PHYSICAL FITNESS TESTS

The preceding portion of this chapter has discussed why certain tests were incorporated into the physical fitness test portion of the Project Mercury Candidate Evaluation Program. When there were significant departures from previous techniques, these were detailed and the reasons were defended. The remainder of this chapter will be devoted to a detailed description of the techniques, results, and interpretation of each test.

Harvard Step Test (see figure 6.1):

Equipment:

a. Platform - 19-1/2 inches high, rubber top, nonskid type, top area 2 feet square

b. Metronome capable of 1 beat/second

c. Clock with sweep second hand

d. Counter to record number of steps climbed

Technique:

The subject dressed himself in long cotton underwear (lower torso portion only), cotton socks, and tennis shoes. He was thoroughly briefed on how to accomplish the test. The metronome was calibrated against an electric clock for 30 seconds before each test. The investigator demonstrated that the subject was to step upon the platform during the first second, step down during the second second, step up during the third second, and continue this performance for 5 minutes. The subject was advised that he might crouch forward as low as he chose when stepping up, thus negating the necessity of coming to a full upright position on the step. Many subjects will fall behind the metronome if they are directed to come to an erect position on the step. The subject was further advised that if he was unable to keep up with the metronome, he was to continue as near as possible to a metronome pace. This last direction was a necessary modification since the close schedule of the NASA candidates rendered it impossible to schedule each subject for more than one test. When the subject stumbled or fell he was encouraged to continue the test if he was not injured. The metronome was then started, and as soon as the subject began his first step-up the clock was started. During the test no encouragement or directions other than repetition of those stated above were given. At the end of 5 minutes the subject immediately sat down. The investigator recorded his pulse during the following three time periods, the end of the test being considered time zero: from 1 to 1-1/2 minutes, from 2 to 2-1/2 minutes, and from 4 to 4-1/2 minutes. All pulses were recorded by precordial auscultation. The recording of the pulses ended the test.

* Hale and Kratochvil of the School of Aviation Medicine, Randolph Air Force Base, Texas, generously offered the assistance of their laboratory. This contribution was gratefully accepted.

Figure 6.1. Harvard Step Test

Example Record:

Pulse 1 to 1-1/2 Minutes after Test = 79 x 2 = 158 beats/minutes

Pulse 2 to 2-1/2 Minutes after Test = 73 x 2 = 146 beats/minutes

Pulse 3 to 3-1/2 Minutes after Test = 64 x 2 = 128 beats/minutes

Total Pulse = 432

Number of Steps Climbed = 111

Scoring:

Two important subject responses were reflected in the scoring system which was adopted:

a. A high postexercise pulse is believed to reflect poor physical fitness.

b. A low number of step-ups reflects poor subject participation.

The total step-up value (S) was divided by the total pulse value (P) and multiplied by 150 to give the final Harvard step test score. (For simplicity of scoring, all final scores were programmed to fall between 0 and 100.) Thus,

$$\frac{S}{P} \times 150 = \text{score}$$

Using above example, the final score would be:

$$\frac{111}{432} \times 150 = 39$$

Results:

All candidates were able to perform for 5 minutes. Four candidates were unable to keep up with the metronome and executed less than 140 steps during the test. The mean step test score was 52.8. The standard deviation (σ) was 5.3.

Narrative Example Performances:

Two separate narrative summaries of subject performances are as follows:

a. Subject performed the test with considerable difficulty. After 2 minutes, he was not able to keep up with the metronome. He was instructed to keep up as steady a pace as possible. He succeeded in completing the 5 minutes, but only climbed 111 steps with a very high pulse, giving a score of 39.

b. Subject performed this test with great ease and during the last 30 seconds increased his pace well above metronome tempo to pick up an additional 5 steps just to see if it could be done. His score was 58.7.

Interpretation:

The coinvestigators interpreted an above average score as desirable and a crude expression of better than average physical fitness. Likewise, they interpreted a lower than average score as a reflection of poorer than average physical fitness and undesirable.

Flack Test:

Equipment:

a. Rubber mouthpiece with connecting tubing

b. Mercury column manometer

c. Electric clock with sweep second hand

Technique:

Subject sat on a chair in front of equipment. He was instructed as follows: "The goal of this test is to hold the pressure as long as you can. Do not hyperventilate before the test. Place the rubber mouthpiece into your mouth. Take in a moderate breath, then blow into the mouthpiece in such a manner as to support the column of mercury at 40 mm. As soon as the column reaches a height of 40 mm. the time clock will be started. You will not be able to see the clock during the test. Do not lock the air pressure in your mouth with your vocal cords closed but let the pressure continuously come from inside your chest. You may make a tighter seal between your lips and rubber mouth hose by use of your hands. The mercury column may fluctuate above 40 mm. but as soon as the height of the column drops below 40 mm. the clock will be stopped. There will be only one opportunity to perform this test." When the investigator was satisfied that the subject understood the directions, the subject was instructed to begin. He was carefully observed to see that he was following directions. Facial plethora and jugular vein distension imply a high intrathoracic pressure and mean the subject is performing correctly.

Scoring and Results:

The score is that elapse of time in seconds from the moment the rising mercury column first reaches a height of 40 mm. until the subject is exhausted and unable to hold it at or above 40 mm. The mean time was 66 seconds; σ was 31 seconds. No one performed more than minus 2 σ from the mean. One candidate was 2.3 σ above the mean. Another candidate was 3.4 σ above the mean. Both of these performances are outstanding. Both were chosen as Mercury Astronauts.

Narrative Example Performances:

Two separate narrative summaries are as follows:

a. This subject had the best performance of the entire group on this test, holding the column of mercury for a total of 171 seconds.

b. The subject performed the Flack test in a substandard fashion, holding the column of mercury for only 27 seconds.

Interpretation:

The coinvestigators interpreted the test results to crudely represent motivation. Those who performed longer appeared to have better than average motivation.

Valsalva Overshoot Test (see figure 6.2):

Equipment:

a. Same as for Flack Test and, in addition,

b. Sphygmomanometer

c. Stethoscope

Technique:

Subject sat comfortably on a chair. Three resting systolic blood pressures were recorded at 1-minute intervals. Then the investigator inflated the blood pressure (BP) cuff to 160 mm. Hg, placed the stethoscope in place over the brachial artery, and instructed the subject to blow into the mouthpiece and support the mercury column to a height of 50 mm. for 15 seconds. As soon as the column attained a height of 50 mm. an assistant started the electric clock. At the end of 15 seconds the assistant instructed the subject to breathe out normally and relax. Immediately after the breath was exhaled a systolic pressure was recorded utilizing the technique recommended by the American Heart Association.*[6,7] After a 1-minute rest, a second test identical to the first was performed. A total of five tests was accomplished. Each time the post breath holding systolic blood pressure was recorded.

Example Record:

Resting Systolic	Test Systolic
1. 116 mm. Hg	1. 124 mm. Hg
2. 124 mm. Hg	2. 126 mm. Hg
3. 122 mm. Hg	3. 124 mm. Hg
	4. 120 mm. Hg
	5. 116 mm. Hg

Scoring:

The coinvestigators developed a simple formula to express the relative rise in systolic pressure during the test:

$$s_2 - s_1 = \text{score}$$

s_2 is the average test systolic value

s_1 is the average resting systolic value

Results:

The mean test score was 4.9. The σ was 9.3 One test was not performed because of an insolvable scheduling problem. Eighty-three per cent of candidates tested were within 1 σ of the

* This suggests that the mercury column of the sphygmomanometer be lowered at 3 mm./pulse beat to record indirect blood pressures.

Figure 6.2. Valsalva Overshoot Test

mean. This is not surprising, since there were no great differences in the systolic pressure recordings during the test when compared with the resting readings. The following explanation is the probable reason why indirect systolic pressure measurements do not show the marked rise in systolic pressure that is seen when taking direct arterial pressures. After the subject releases the high intrathoracic pressure, there are about 5 to 10 seconds during which the systolic pressure rises and falls. The blood pressure cuff is pressurized to 160 mm. Hg. Assume that a simultaneous direct arterial pressure reveals the actual highest systolic overshoot to be 140 mm. Hg 2 seconds after the breath is released. It will be impossible to obtain this value by indirect methods, following the American Heart Association recommendation. The pressure cuff must be reduced from 160 to 140 before the systolic pressure is identified. This is a drop of 20 mm. Hg. The pressure cuff is reduced at a rate of 3 mm. Hg per second. In 7 seconds the cuff pressure will be approximately 140 mm. Hg. By then the actual arterial pressure is less than its maximum. This is the main experimental error, and it is of sufficient magnitude to give a narrow group spread.

Interpretation:

The coinvestigators did not interpret the test because of the significant experimental error.

Cold Pressor Test (see figure 6.3):

Equipment:

a. Electric clock with second hand

b. Sphygmomanometer

c. Stethoscope

d. Basin about 4-1/2 to 5 inches deep and 12 inches in diameter filled with ice water, average temperature of 4° C.

Technique:

The subject did not receive any pretest briefing. Three resting blood pressures and pulses were taken at 1-minute intervals, while the subject relaxed in a chair with his bare feet on the floor. Room temperature was 68° to 74° F. Immediately following the third resting blood pressure, an assistant brought the prepared pan of ice water and placed it in front of the subject. The investigator then directed the subject to plunge both of his feet into the ice water, and leave them there for 7 minutes. The subject was advised that this was the only opportunity he would have to perform this test and that he would be expected to keep his feet in the ice water the entire time. Immediately after plunging the feet, the clock was started. A blood pressure and pulse were recorded each minute during the test. If the subject removed his feet from the water before the elapse of 7 minutes, it was so recorded and the experiment was terminated. At the end of 7 minutes, or sooner if there was a premature withdrawal, the subject placed his feet on a dry towel. Three posttest blood pressures and pulses were then recorded. The subject was instructed not to discuss this test with any of the other candidates.

Figure 6.3. Cold Pressor Test

Example Record*:

	Blood Pressure	Pulse
Resting		
1 min.	112/64	70
2 min.	116/68	70
3 min.	118/70	70
Average	115/67	70
Feet in Ice Water		
1 min.	140/70	108
2 min.	142/76	108
3 min.	136/84	74
4 min.	132/76	80
5 min.	138/86	80
6 min.	148/86	76
7 min.	140/84	84
Average	139/80	87
Feet out of Ice Water		
1 min.	128/76	76
2 min.	128/76	72
3 min.	128/76	76
Average	128/76	75

Scoring:

It was desirable to reduce these many bits of raw data into a final, meaningful, numerical score. To achieve this data reduction the investigators jointly agreed upon the following:

* This subject was quiet and cooperative and offered no complaints.

a. The average resting pulse is subtracted from the average pulse during immersion in the cold water (termed p_1). Using the example:

$$p_1 = 87 - 70 = 17$$

b. The average resting pulse is subtracted from the average posttest pulse (termed p_2). Using the example:

$$p_2 = 75 - 70 = 5$$

c. The sum of $p_1 + p_2 = P$. Thus,

$$17 + 5 = 22$$

d. The same method was adapted to reduce systolic pressures to simple numbers. The average pretest systolic pressure subtracted from the average test systolic pressure is termed s_1. The average pretest systolic pressure subtracted from the average posttest systolic pressure is termed s_2. The sum of $s_1 + s_2 = S$. Thus,

$$s_1 = 139 - 115 = 24$$

$$s_2 = 128 - 115 = 13$$

$$S = s_1 + s_2 = 37$$

e. The same method was also used for the diastolic pressures. The difference between the test and resting average diastolic pressures is termed d_1. The difference between the posttest and resting average diastolic pressures is termed d_2. The sum of $d_1 + d_2 = D$. Thus,

$$d_1 = 80 - 67 = 13$$

$$d_2 = 76 - 67 = 9$$

$$D = 13 - 9 = 22$$

f. The final score, the sum of P + S + D, is termed Q. Thus,

$$Q = 22 + 37 + 22$$

$$Q = 81$$

Results:

Three subjects withdrew their feet from the ice water before the end of the test. The longest immersion time of those three was 45 seconds. The mean Q value was 37. The σ was 37. There were no episodes of hypotension, presyncope, or syncope.

Narrative Example Performances:

Two separate narrative summaries are as follows:

a. This subject complained bitterly when presented with this test and stated that he was sure he would be unable to keep his feet in the water. When he was finally convinced that it was necessary, he placed his feet into the water, complaining bitterly all of the time. At the end of 15 seconds, he complained of severe pain and withdrew his feet. He made a halfhearted second try, but finally refused any further attempt. His resting blood pressure was 119/60, his resting pulse, 85. Immediately after placing his feet into the water the first time, his blood pressure rose to 150/110.

b. This subject performed the test with very little comment and very little apprehension. However, his blood pressure and pulse rose markedly during the time his feet were in the water and he sustained a systolic elevation even after his feet were removed from the water. His score was 91.

Interpretation:

The hypertension and tachycardia were intentionally not interpreted, so that they could be used in the correlation study. The coinvestigators interpreted withdrawal of the feet from the ice water before the end of the test as a reflection of poor motivation.

Treadmill Test (see figure 6.4):

Equipment:

a. Treadmill with belt speed of 91.5 meters/minute capable of being elevated to a maximum angle of 25°.

b. Sphygmomanometer

c. Stethoscope

Technique:

Subject was dressed in lower trunk cotton underwear, socks, and tennis shoes. Subject sat at rest on the treadmill while 3 resting blood pressures and pulses were recorded at 1-minute intervals. This was accomplished by securely placing a BP cuff and stethoscope on the left arm and an additional stethoscope on the precordial area. The subject then stood astride the leather treadmill belt and received this briefing: "The treadmill motor will be switched on. It will run at a constant speed of 91 meters/minute (3.4 miles/hour). At the end of each minute, the angle of inclination of the treadmill will be increased to 0.9° (1% of 90°), starting from the horizontal. Thus, at the end of 1 minute the treadmill will be raised from 0 (horizontal) to a 0.9° angle. At the end of 10 minutes, it will be raised from a 7.2° angle to an 8.1° angle. The test will terminate for any of the following reasons:

a. If you are experiencing any unbearable discomfort

b. When your pulse reaches 180 beats/minute and remains there at least 1 minute

c. At the discretion of the physician

You may not hold onto the support rails unless you terminate." The treadmill was then started, and, when the subject walked on it without holding the side supports, the test commenced.

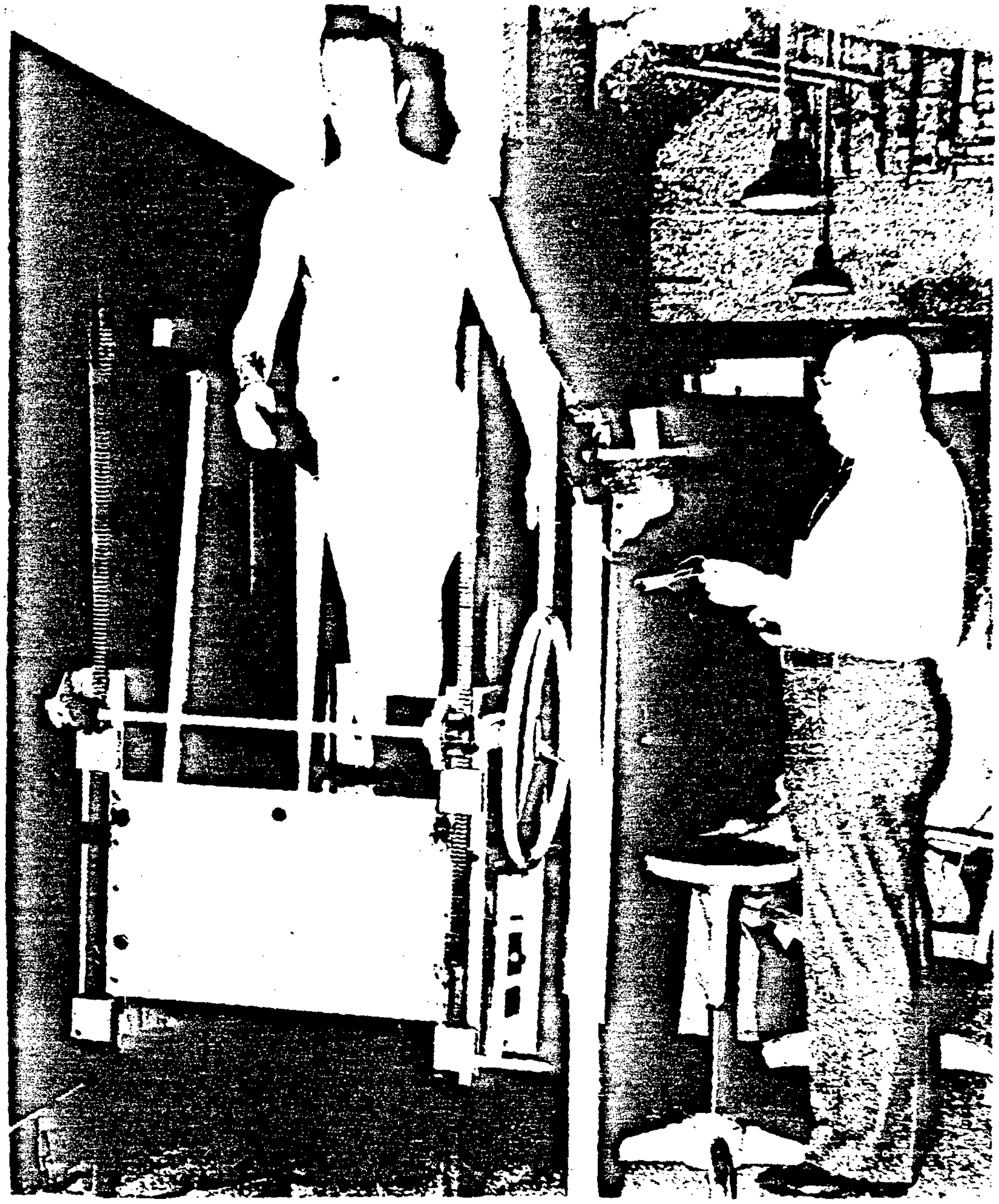


Figure 6.4. Treadmill Test

Example Record*:

	Blood Pressure	Pulse
Resting		
1 min.	98/66	112
2 min.	94/60	110
3 min.	96/66	108
On Moving Treadmill		
1 min.	120/80	120
2 min.	110/70	152
3 min.	140/80	160
4 min.	120/80	164
5 min.	128/90	172
6 min.	126/90	176
7 min.	140/80	180
8 min.	140/80	186
9 min.	150/80	194
After Test		
1 min.	140/50	168
2 min.	116/60	156
3 min.	118/58	142

Scoring:

The coinvestigators reasoned that a lower than average test pulse reflected better than average physical fitness. To arrive at a final score, the number of minutes (M), during which the subject's pulse did not exceed 180, was divided by the average test pulse (P), excluding pulses above

* This subject volunteered to perform longer, stating he felt quite well. This record was included because it is unusual. The subject has had a high resting pulse for years. This may explain his low time score and identifies a weakness in the present endpoint and scoring system.

180. The quotient multiplied by 1000 gave S, the final treadmill test score. Thus,

$$S = \frac{M}{P} \times 1000$$

Using the above example:

$$M = 7$$
$$P = 161$$

Thus, the final score would be:

$$S = \frac{7 \times 1000}{161} = 43$$

Results:

The mean final score was 75. The σ was 15. One subject was 2.2 σ below the mean. Another subject was 2.4 σ above the mean. All others were within 2 σ of the mean.

Narrative Example Performances:

a. The subject performed the test cooperatively, but was very clumsy. He had a wide, "stomping" gait on the treadmill. His final score was 85.

b. This subject established the record for the candidates. He performed for a total of 16 minutes, attaining a score of 110.

Interpretation:

The coinvestigators interpreted a greater than average test time and a less than average test pulse as a reflection that the subject was in better than average physical fitness. They also interpreted a less than average test time and a more than average test pulse as a reflection that the subject was in poorer than average physical condition.

Partial Pressure Suit Test (see figure 6.5):

Introductory Remarks:

The MC-1 partial pressure suit, when worn in the low-pressure chamber at 42 mm. Hg (65,000 feet barometric equivalent) for 1 hour, presents definite physiological and psychological stresses. The suit only has a small anterior chest and abdominal bladder. This bladder does not offer adequate counterpressurization on the outside of the entire torso to equalize the high intrathoracic pressure. In effect, pressure breathing is necessary.

The most important physiological response to the MC-1 pressure suit test is the alarming frequency of sudden presyncope. The pattern leading up to syncope is fairly uniform. The subject is exposed to a simulated altitude of 65,000 feet. Suddenly he breaks into moderate diaphoresis on his entire body. He discerns this easily on his arms and legs where the sweat evaporates through permeable fabric. The effect is a cold sensation such as evaporating ether. Concomitantly, there is a definite hypotension and a relative bradycardia. True bradycardia implies the pulse is below 60 beats/minute. However, in the MC-1 suit during the test, a sudden drop in pulse from 150 to 75 (figure 6.6) is a relative bradycardia. The subject becomes ghostly pale and often states that his field of vision is constricting and that he is "graying-out." If another few seconds are inadvertently allowed to

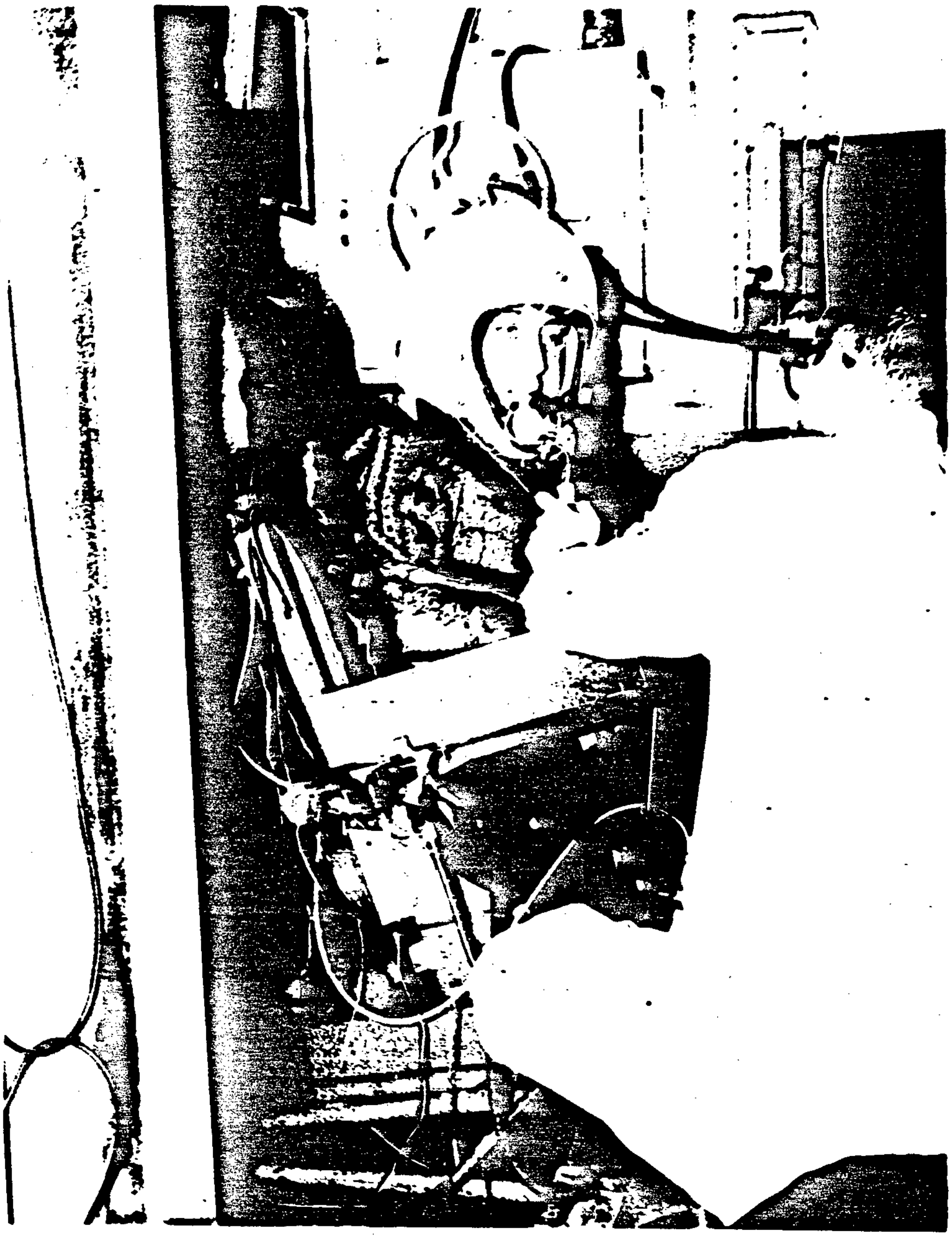


Figure 6.5. MC-1 Test. Checking Equipment Prior to Test

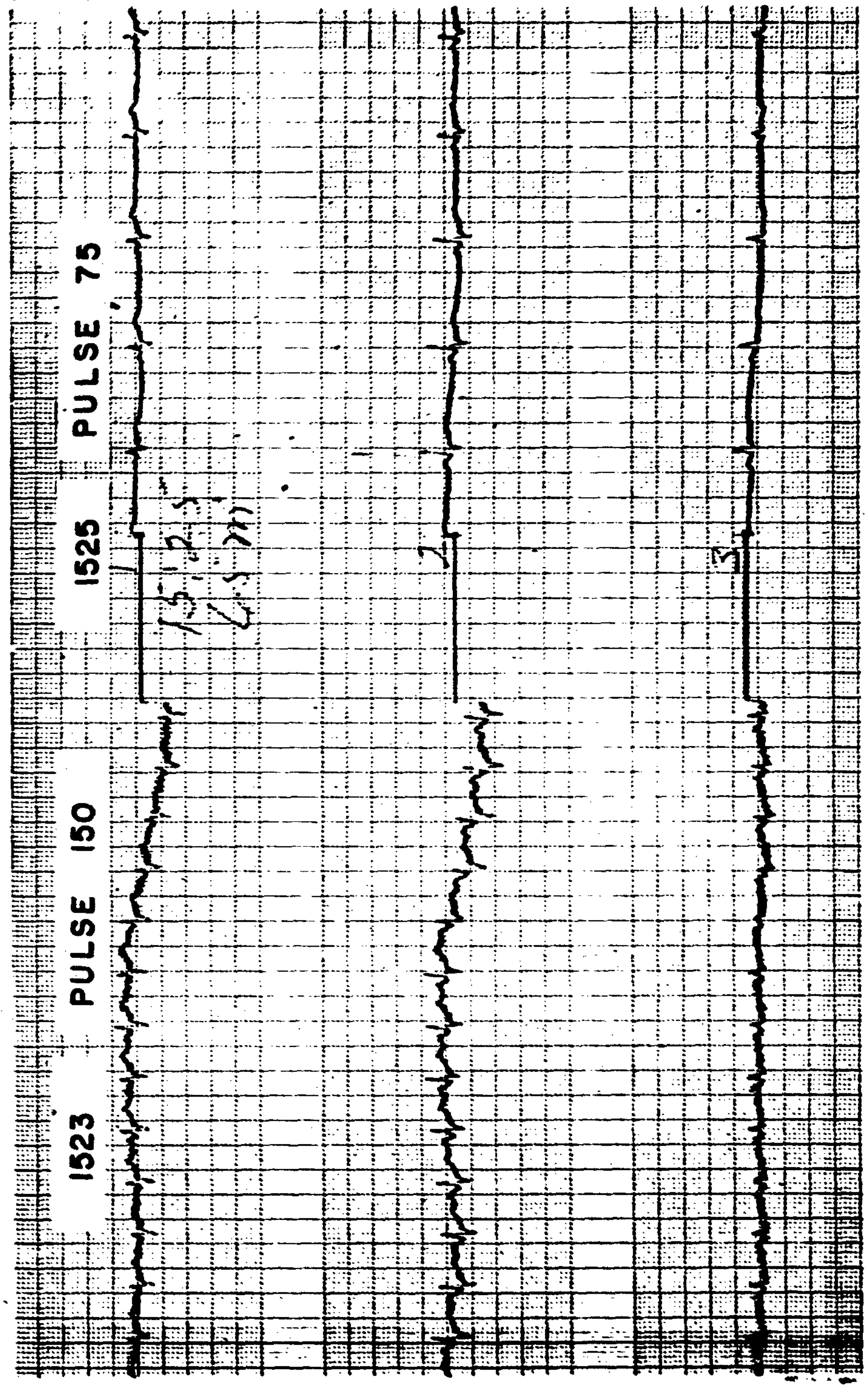


Figure 6.6. MC-1 Test. Bradycardia

elapse, the subject becomes unconscious and slumps forward in his ineffectively counterpressurizing suit. Emergency repressurization of the chamber from 65,000 to 40,000 feet will deflate the suit in 4 to 6 seconds. Return to consciousness occurs in another 4 to 6 seconds. The pallor, clammy skin, hypotension, and bradycardia often persist for 1 to 2 hours after cessation of the test. The lapse of time from the first symptoms until syncope varies from a few seconds to 2 minutes. As soon as the first symptoms appear, the test is immediately terminated to avoid unconsciousness.

The following physiological or psychological reasons for termination in 56 attempted MC-1 suit tests were observed: unconsciousness, 2; presyncope, 5; tachycardia greater than 160 beats/minute, 3; claustrophobia, 1; hyperventilation with apprehension, 2; and inability to breathe adequately in suit, 1. Thus, 14 (25%) of 56 attempted tests were terminated for physiological or psychological reasons.

Equipment:

a. Low-pressure chamber, capable of attaining 42 mm. Hg pressure

b. MC-1 partial pressure suit ensemble

c. MA-2 helmet, pressure gloves, regulator, oxygen

d. Extremity EKG leads

e. Oscilloscope

f. Direct write-out EKG machine

g. Emergency equipment: oxygen, resuscitator, bronchoscope, laryngoscope, tracheal catheters, thoracotomy set, heart defibrillator, and pace-maker machine; appropriate electrolyte solutions to stimulate cardiac muscle

h. Floodlights in chamber

i. Movie camera

Technique:

Starting at 0800 or 1300 hours the subject dressed in long underwear, personal socks, and shoes, sat in a comfortable chair, and denitrogenated on 100% oxygen for 2 hours. He wore an MA-2 helmet and facepiece, with 8 mm. Hg positive pressure delivered from an MQ-1 console. As soon as he began denitrogenating he was fitted into an MC-1 partial pressure suit. A choice of suit size was made from the subject's stated height and weight. When dressed in the suit, the lacings were appropriately adjusted and a final assessment of suit fit made by the physician. The same physician conducted all of these MC-1 tests. In two cases tailoring of the arms or legs was accomplished. The MA-2 helmets were individually fitted by tightening the lacings. Each subject was fitted with the appropriate size of pressure gloves. The feet were not counterpressurized. Extremity EKG leads were applied to each subject. Blood pressure recordings were not incorporated because of the technical unreliability of the present strain gauge under a pressure suit. During the final 30 minutes of denitrogenation the subject experienced a battery of tests:

a. He performed several written tests which were designed to measure a variety of psychomotor functions.

b. Following the psychological tests, 15 cc. of venous blood was drawn from the subject. The blood was heparinized and centrifuged. The plasma sample was labeled with a code number and frozen.*

c. The subject then attempted to empty his bladder and, if successful, a sample of the urine was placed into a polyethylene container with a preservative.**

d. A special analysis of the pre- and post-MC-1 urine samples for 3-methoxy-4-hydroxymandelic acid was accomplished on five of the NASA candidates to determine if there was a correlation between it and corticosteroid and catacholamine. This latter analysis was carried out by Lt. Larry Berman.

e. The subject then entered the low-pressure chamber while breathing from a portable O_2 tank. The following checks were made:

(1) Switch to chamber oxygen supply.

(2) Connect bladder and capstan and helmet hoses to regulator hoses.

(3) Connect and check intercommunication.

(4) Connect and check all EKG leads; check for clarity of EKG write-out.

(5) Inflate the pressure suit to insure appropriate pressures are being delivered to the subject in the suit.

(6) Photograph the subject.

(7) Check the suit and helmet ensemble for final time.

(8) Close the subject chamber.

f. The inside observer assumed his place in the lock.

Prior to this time there had been no detailed briefing of the subject by the physician. The physician sat at a viewing window to the left side of the subject. Before he spoke to the subject, he obtained 3 resting pulses at 1-minute intervals. The exact time of denitrogenation was recorded, as well as details of previous pressure suit experience. When the subject indicated he was prepared, the chamber was evacuated to 40,000 feet. The subject was cautioned to advise the crew if gas pains or discomfort developed. At 40,000 feet, each subject received the following briefing:

"For this test I will assume that you have never had any previous training in pressure suits. Following this briefing and when you say so we are going to take you to 45,000 feet. EKG and pulse recordings will be taken. When you indicate you are prepared, we'll go to 55,000 feet, take EKG and pulse recordings, and then, when you indicate, we'll go up to 65,000 feet. When you reach 65,000, the test will start and continue for 60 minutes unless medically contraindicated.

"Tell me if you have any of the following sensations while being exposed to 65,000 feet barometric equivalent:

---

* These frozen samples were analyzed for plasma corticosteroids by Dr. Henry B. Hale and his staff at the Department of Physiology, School of Aviation Medicine, Randolph AFB, Texas.

** Pre- and post-MC-1 urine samples were mailed to Bio-Science Laboratories, Los Angeles, California. The samples were analyzed for urinary catacholamines.

a. Breaking out into perspiration (This sudden perspiration will not feel like a regular sweat. The evaporation will feel like the coolness when ether evaporates.)

b. Nausea

c. Diminishing vision (like barrel vision) or graying out

d. Faintness, lightheadedness, or dizziness

e. Breathing trouble or not able to take a satisfactory breath

"The chamber crew can usually determine all of these situations long before you. This briefing is intended to insure you of the widest possible margin of safety. While you are at 65,000 feet, we recommend that you keep your movements to a minimum. If you desire to move, you will find that it is a considerable effort. Don't feel that you have to keep looking up. We can see your face even when you look down. Talking will fatigue you and speed your pulse rate. At the end of 10 minutes at 65,000 feet you will read a speech. You may find it a bit of an effort. Keep your talking to a minimum except as indicated. When you are asked a question, do not hesitate or delay the answer. You may nod your head or stick up your thumb in lieu of a verbal reply. If you do not give a prompt reply, I will assume you are in trouble and order an emergency chamber descent.

"Do not do a Valsalva maneuver when passing gas rectally or orally as this frequently causes dizziness and a pulse rise. Relax and the gas will pass easily. When you take in a breath and hold it in your chest, do not close your vocal cords. This is effecting a Valsalva maneuver, too. Keep your eyes open. If you close them, we will immediately repressurize the chamber. It takes only 4 to 7 seconds to bring the chamber to a safe altitude, so you need not be concerned about your safety. Do you have any questions?"

When all questions had been answered and if there was no gas discomfort, the chamber was evacuated to 45,000 feet. At 45,000 feet the capstan pressure must be at least 2.9 p.s.i. and helmet pressure at least 39 mm. Hg. Once the physician established that the subject was breathing without undue difficulty, and that there were no contraindications, he then directed the chamber to be evacuated to 55,000 feet. At this altitude the capstan pressure must be at least 7.0 p.s.i. and helmet pressure at least 72 mm. Hg. After the subject became accustomed to the difficult breathing characteristics and when the subject approved, the chamber was evacuated to 65,000 feet and the 1-hour test commenced. At 65,000 feet the minimum safe capstan pressure is 9.5 p.s.i. and the minimum bladder pressure is 99 mm. Hg. During all of the 60 minutes at 65,000 feet the subject was very cautiously observed by three experienced persons: the physician, the chamber operator, and the inside observer (who was thoroughly briefed in emergency procedures and was at an intermediate altitude of 25,000 feet). The pulse and suit pressures and EKG were routinely recorded at 5-minute intervals. A battery of floodlamps were turned on at 2- to 5-minute intervals to assess the color of the subject's face.

Causes for termination of the test were as follows:

a. If the subject requested termination. Experience has shown that psychological causes are: anxiety, fear, apprehension, and claustrophobia.

b. If the physician ascertained that the subject's well-being was in danger. This includes the following: unconsciousness, presyncope, tachycardia in excess of 160, gas pains, or the bends.

c. Any malfunction of the suit or the seat-kit assembly* or other strategic mechanical failure

---

* The seat-kit assembly contains the suit regulators and hoses.

After the elapse of 10 minutes at 65,000 feet, all subjects read a specially prepared speech entitled, "My Grandfather." This was recorded on tape for analysis of speech intelligibility in a pressure suit. Unless an emergency developed, the subject remained at 65,000 feet for 60 minutes. He was then given the opportunity to briefly experience pressure suit protection at 100,000 feet. If he desired, the chamber was evacuated to 100,000 feet and immediately repressurized to sea level. Taking the subjects to 100,000 feet required 1 to 2 minutes and was not a part of the test. It was intended for familiarization and experience only.

Procedure after the test was as follows:

a. Subject's helmet and gloves were removed and the pressure suit was turned down at the waist for comfort.

b. A 15-cc. venous blood sample was taken from the nonwriting arm, and the plasma was frozen (vide supra).

c. A repeat psychological written test was performed.

d. A urine specimen for catacholamine and 3-methoxy-4-hydroxymandelic acid was taken.

The above procedure completed the MC-1 test. The entire profile required an average of 4 hours.*

Scoring:

Several rules were established in order to score each subject's performance as fairly as possible:

a. Any subject who terminated the test for psychological reasons automatically would receive the poorest possible rating.

b. If a test was terminated for insolvable mechanical reasons, and if it was impossible to reschedule the subject, then the subject would be given the full 60 minutes credit.

c. When a subject developed presyncope or syncope, and the test was terminated, the scoring would apply only to that part of the test which occurred before the signs and symptoms of presyncope.

d. When a subject developed a tachycardia sufficient to terminate the test (160 beats/min. or greater), the scoring would apply only to that part of the test which occurred before the tachycardia reached 160/min.

Scoring utilized the pulse response of the subject. The average of three pulses taken prior to chamber ascent was termed P_r. The average of all pulses taken while subject was at 65,000 feet (but not including those pulses during presyncope, syncope, or tachycardia, 160 beats/min.) was termed P_t. The final MC-1 score was termed S_{mc-1} and represented the difference between P_r and P_t.

Using the following example: $P_r = 83$ and $P_t = 144$

Therefore, the final score would be: $S_{mc-1} = 144 - 83 = 61$

* Then the subject was provided with a shower and 2 ounces of whiskey. The whiskey was not consumed immediately if other tests were planned within 6 hours.

Example Record*:

Time	Chamber Pressure# (mm. Hg)	Duration 65,000 Ft. (minutes)	Pulse (per minute)	Bladder Pressure	Capstan Pressure	Remarks
1522	730		78	6	0	
1523	730		88	4	0	
1524	730		83	6	0	Denitrogenation-2hr., 20 minutes
1527	141		88	8	0	No previous pressure suit experience
1533	110		92	34	3.0	Not experiencing difficulty
1534	68		104	78	8.0	Color and EKG normal
1537	42	Start	132	104	11.0	Color and EKG normal except
1542	42	5	128	102	11.0	for tachycardia; no complaints
1547	42	10	132	100	11.0	Read "My Grand-father" speech and
1552	42	15	144	102	11.0	pulse rose to 144 beats/min.; advised
1557	42	20	144	104	11.0	subject to keep activity and talking to minimum.
1602	42	25	148	100	11.0	Moderate suboccipital ache due to helmet pressure
1607	42	30	152	104	11.3	Color and EKG are unchanged since
1612	42	35	152	106	11.5	start, except for rising tachycardia.
1617	42	40	150	104	11.0	Subject is obviously experiencing helmet
1622	42	45	150	106	11.0	discomfort but not complaining.
1627	42	50	152	104	11.0	
1632	42	55	150	102	11.0	Subject is becoming very pale.
1637	42	60	144	104	11.0	Helmet ache is severe, but subject desires to finish test.
1643	730		80	6	0	Monitor unwilling to let subject ascend to 100,000 feet

\# 730 mm. Hg is equivalent to ground level
141 mm. Hg is equivalent to 40,000 feet altitude
110 mm. Hg is equivalent to 45,000 feet altitude
68 mm. Hg is equivalent to 55,000 feet altitude
42 mm. Hg is equivalent to 65,000 feet altitude

* The medical monitor was impressed with this subject's demonstration of motivation.

Results:

a. Thirty-one MC-1 tests were attempted. Twenty-two subjects successfully completed the 1 hour at 65,000 feet. The causes for the nine terminations were:

(1) Presyncope (relative bradycardia, pallor, faintness)	4 subjects
(2) Psychological termination	2 subjects
(3) Tachycardia	1 subject
(4) Intercommunication failure	1 subject
(5) Unable to fit subject to protect neck area properly	1 subject

b. The mean resting pulse was 82 beats/minute. The mean test pulse (not including those during presyncope or tachycardia of 160) was 109 beats/minute. The mean S_{mc-1} was 27. The σ for the S_{mc-1} was 16. Two subjects had scores which were greater than 2 σ above the mean. No subject had a score of less than the mean minus 2 σ.

Narrative Example Performances:

a. Subject had not had previous pressure suit experience, but performed extremely well by rapidly adapting to the stressful situation. He responded quickly with answers and was so much at home in the threatening situation that he experimented and discussed in detail various breathing cycles that he was performing as well as various motions with his arms and legs to test the mobility of the suit.

b. The subject had had previous experience in the MC-3 pressure suit to 65,000 feet barometric equivalent for 15 minutes. The subject's first attempt at this pressure suit test aborted because the subject had intense gastric distress which he was unable to relieve. It was the observer's impression that the subject tried to be fully cooperative in attempting to relieve this gas. The subject spent an hour attempting to relieve this distress. He was unsuccessful and the run was finally aborted by the physician. The remainder of that day was spent performing other physiological tests.

Two days later the subject again denitrogenated for 2 hours and as the blood sample was drawn from his arm, he remarked frequently and bitterly about having to submit to blood sampling. He was moderately abusive to the medical observers who were drawing the blood samples and complained with equal bitterness to the airmen that the MC-1 was a poor and inadequate pressure suit. Everyone who worked with him that morning was impressed that this subject was antagonistic and moderately uncooperative. The chamber was evacuated by the carefully programmed profile to 65,000 feet barometric equivalent. The subject experienced hyperventilation and great difficulty in breathing adequately. The subject turned his thumb down, indicating he wished to be returned to a 40,000-foot altitude. This was immediately accomplished. The total duration of this test at 65,000 feet was 2 minutes, 50 seconds. The subject agreed to attempt the return to 65,000 feet. This was accomplished and this time he remained 2 minutes, 12 seconds. Again he indicated to the physician that he wished to return to sea level, stating: "I'm sorry; I just can't hack it. I guess I was hyperventilating." The physician in charge was impressed that this subject lacked motivation during this test and was not making an effort to learn to breathe in the MC-1 suit. There were no physiological reasons for termination of the test.

Interpretation:

a. The subjects who terminated the test for psychological reasons were not well motivated, and/or were not able to conquer their apprehensions. A candidate who terminates for psychological reasons is not, under any circumstances, suitable for recommendation by the physical fitness investigators.

b. The subjects who had an average test pulse rise less than the group average test pulse rise were in better than average physical fitness. The subjects who had an average test pulse rise greater than the group average test pulse rise were in poorer than average physical fitness.

c. No significance was attached to the occurrence of presyncope or tachycardia. It was interpreted as representing a normal variation in physiological response to the stress of severe positive pressure breathing. Dermksian[6,8] has reported syncope, presyncope, and cardiac arrhythmias due to breath holding in normal, healthy pilots. The bradycardia is possibly due to stimulation of the efferent cardiac decelerator nerves by lung stretch receptors. It is reasonable to suspect that atropine might prevent further bradycardias, as Dermksian reported.

Tilt Table Test (see figure 6.7):

Equipment:

a. Tilt table capable of rotating from the horizontal to a 65° inclination.

b. Harvard step platform

c. Clock

d. Metronome

e. Sphygmomanometer

f. Stethoscope

Technique:

Subject wore long underwear on the lower torso and was fitted with a blood pressure cuff and stethoscope. Three sitting blood pressures and pulses were recorded at 1-minute intervals. Then the subject performed the Harvard step test for 3 minutes as described (vide supra). Immediately upon completion of the exercise he stood upon the tilt table with his feet on a fixed platform, previously adjusted to the subject's comfort (figure 6.7). The head of the tilt table had been set at 65° from horizontal. Subject was then instructed to relax, not to move his arms, legs, or hips, and to avoid unnecessary talking. During each minute of the 25 minutes with the tilt table at 65° the pulse and blood pressure were recorded. If the subject was nauseated or pale it was noted. When syncope or vomiting was imminent, the test was terminated. If the subject did not follow directions this was noted. Following 25 minutes of standing on the tilt table at 65° the subject was returned to the horizontal. Three final blood pressures and pulses were recorded at 1-minute intervals.

Example Record:

During the following example test, the subject was very cooperative. He experienced no nausea and no pallor or marked sweating. His average pretest blood pressure was 116/70 and his average test pulse was 138. The test systolic was less than the average resting systolic by >6 mm. Hg during minutes 14, 15, 18, 21, 22, 23, 24, and 25. The test diastolic was never less than the average resting diastolic by >6 mm. Hg. The total number of minutes that the systolic and/or diastolic was less than resting blood pressures was 8 minutes.

Figure 6.7. Tilt Table Test

	Blood Pressure	Pulse
Resting		
1 min.	120/70	100
2 min.	114/70	100
3 min.	114/70	96
After Exercise		
1 min.	158/70	200
2 min.	158/70	196
3 min.	138/80	160
4 min.	134/80	140
5 min.	134/80	124
6 min.	128/80	132
7 min.	124/76	136
8 min.	124/80	124
9 min.	110/76	124
10 min.	120/80	136
11 min.	120/84	124
12 min.	118/80	132
13 min.	110/84	140
14 min.	100/80	132
15 min.	104/80	140
16 min.	116/80	128
17 min.	110/84	136
18 min.	108/88	128
19 min.	110/86	132
20 min.	112/84	140
21 min.	106/80	136
22 min.	102/80	132
23 min.	100/82	128
24 min.	100/80	128
25 min.	98/84	132
Subject Horizontal		
1 min.	110/78	112
2 min.	110/70	112
3 min.	110/78	100

Scoring:

This arbitrary scoring system was designed to render a low final score for subjects with bradycardia, hypotension, and syncope. A higher than average resting blood pressure and tachycardia produced a high score. A formula was developed to reflect the change of pulse and blood pressure. The average pulse value was divided by a constant (4) to keep the final score below 100.

The average pulse during the test was termed P_t. The number of minutes that the systolic and/or diastolic blood pressure was significantly lower than the average resting systolic and/or diastolic blood pressures was termed M. (If any test systolic pressure was 6 mm. Hg or more less than the resting systolic pressure, or if any test diastolic pressure was 6 mm. Hg or more less than the resting diastolic pressure, this was considered significantly lower than the average resting blood pressure.) The final score was termed S. The formula used for final scoring was:

$$S = 25 - M + \frac{P_t}{4}$$

Using the above example:

$$\frac{P_t}{4} = 35$$

$$M = 8$$

Therefore, the final score would be:

$$S = 25 - 8 + 35 = 52$$

Results:

Thirty-one tilt table tests were administered. Twenty-four were uneventful. (In this sense, uneventful means that the subject performed the test properly and/or that the subject's medical signs and symptoms were not of sufficient magnitude to terminate the test.) The other seven tests were considered eventful due to the following:

(1) Presyncope (hypotension, pallor, lightheadedness) causing termination of test	6 subjects
(2) Uncooperative subject; did not follow directions	1 subject

Two of the subjects who demonstrated presyncope were ill prior to the test. They were inadvertently tested during their illnesses. Since their presyncope might well have been precipitated by their illnesses, they were retested at another time when they were well. Both performed uneventfully when retested. A third subject who was not ill, and who developed presyncope, was also retested at his request and performed uneventfully during retesting. Therefore, there were three remaining subjects who had developed presyncope but were not afforded a chance to attempt to establish a higher score.

Interpretation:

There were inconsistencies in the administration of this test. Three subjects experienced presyncope. They were retested and performed uneventfully. It would not be equitable to compute a score based on the tilt table response during illness. It also would not be equitable to score the remainder of the healthy population, unless they were also retested and given an equal chance to attempt to establish a higher score.

METHOD OF RANKING CANDIDATES

The candidates who aborted the MC-1 partial pressure suit test or the cold pressor test for psychological reasons were automatically ranked lowest. The remaining candidates were ranked by an analysis of their final scores on the Harvard step test, the Flack test, the treadmill test, and the MC-1 partial pressure suit test. Table 6.1 presents all of the performance scores of the candidates on the physical fitness tests.

Scoring Technique:

1. The mean score was subtracted from the score of the candidate.

2. The standard deviation was determined for each of the tests.

3. Then it was determined how greatly the subject's score differed from the mean. This difference was expressed as σ from the mean for each subject.

4. Each subject's score on each of the four tests was expressed as σ from the mean.

5. The algebraic sum of σ from the mean on these four tests was the final physical fitness score of the candidates.

The following are examples of the scoring technique:

Example Subject	The Mean Score Subtracted from the Subject's Score				The Subject's Score Expressed as σ from the Mean Score				Physical Fitness Score
	Harvard	Flack	Treadmill	MC-1*	Harvard	Flack	Treadmill	MC-1	
K	+11.1	+104.8	+34.6	+23.6	+2.10	+3.34	+2.37	+1.47	+9.28
AA	+ 1.4	- 1.2	+19.6	-13.4	+0.26	-0.04	+1.34	-0.84	+0.72
Q	-13.8	- 24.2	-21.4	- 0.4	-2.60	-0.77	-1.47	-0.30	-4.87

Harvard Mean	= 52.8	Harvard σ	= 5.3
Flack Mean	= 66.2	Flack σ	= 31.3
Treadmill Mean	= 75.4	Treadmill σ	= 14.6
MC-1 Mean	= 26.6	MC-1 σ	= 16.0

Table 6.2 is a complete list of the scores of the candidates. Table 6.3 shows the final candidate ranking.

Interpretation:

The candidates who had higher total scores and are at the top of the ranking list are in better physical fitness than those candidates who had lower total scores and are at the bottom of the list. The candidates in a better state of physical fitness are more desirable for Project Mercury.

* The mean score was subtracted from the subject's score, but + and - were reversed as low pulse change is more desirable.

TABLE 6.1

PERFORMANCE SCORES OF CANDIDATES ON PHYSICAL FITNESS TESTS

Subject	Harvard Step Test: Number of Steps	Harvard Step Test: $\frac{S}{P} \times 150$	Flack Test 40 mm. Hg Held in Seconds	Valsalva Overshoot $S_2 - S_1$	Cold Pressor Test Final Score	MC-1 Suit Test $P_1 - P_r$	Tilt Table Test Final Score	Treadmill Test Final Score	Free Hydrocortisone in μg./100 ml. plasma: Before MC-1	Free Hydrocortisone in μg./100 ml. plasma: After MC-1	Adrenalin in μg./100 ml. urine: Before MC-1	Adrenalin in μg./100 ml. urine: After MC-1
A	142	49.0	89.0	4	4	16*	46	71	13.8	16.6	6	No record
B	152	49.6	90.0	4	100	28	54	66	10.5	11.4	Less than 2	Less than 2
C	152	49.8	70.0	8	35	15	42	77	14.5	17.4	3	2
D	135	47.0	43.0	4	36	12	57	44	No record		10	No record
E	144	50.0	65.0	4	32	18	43	80	11.6	9.4	2	2
F	148	54.4	33.0	1	100	38**	54	75	10.2	15.5	3	8
G	143	55.9	52.0	13	40	4	50	88	11.4	15.6	2	6
H	154	62.1	81.0	-4	44	27	43	73	18.2	20.8	2	5
I	142	50.2	26.5	11	-38	31	38	65	19.1	13.4	Less than 2	7
J	150	44.9	66.0	8	18	61	51	74	22.1	8.4	Less than 2	No record
K	150	63.9	171.0	2	91	1	50	110	13.2	16.1	Less than 2	Less than 2
L	149	54.7	91.0	13	22	31	49	85	9.1	10.6	4	5
M	150	50.1	52.5	18	68	28	55	58	20.3	20.1	Less than 2	3
N	157	57.7	27.0	10	19	--**	53	69	14.4	12.1	Less than 2	4
O	135	50.1	34.5	Not performed	23	7	27	58	4.7	8.0	2	4
P	141	51.2	95.0	15	45	29*	43	85	9.5	17.1	Less than 2	No record
Q	133	39.0	42.0	2	37	27*	60	54	8.3	12.3	2	Less than 2
R	150	56.0	49.0	11	43	12	45	83	15.3	11.2	2	3
S	142	56.0	32.0	0	20	14	50	89	7.6	11.5	6	5
T	144	52.7	35.0	-15	79	66***	45	94	No record		3	Less than 2
U	146	49.1	60.0	4	21	42	56	61	14.8	25.2	3	5
V	150	54.9	93.0	2	5	12	54	79	19.5	18.6	No record	3
W	140	42.7	60.0	-13	72	39	57	57	11.8	16.2	4	7
X	150	49.5	61.0	-2	100	50	51	70	10.8	18.0	Less than 2	Less than 2
Y	147	59.6	65.0	5	50	15	52	70	No record		3	0
Z	143	60.4	48.0	0	-60	10	31	60	6.7	14.8	No record	Less than 2
AA	147	54.2	65.0	3	37	40	53	95	15.6	18.8	3	7
BB	150	57.6	94.0	-2	45	3	53	86	9.5	14.1	2	Less than 2
CC	147	51.7	53.0	1	3	45***	37	74	17.3	26.8	4	8
DD	136	54.0	71.0	18	67	12*	37	97	14.0	14.5	4	5
EE	155	58.7	139.0	2	-8	23	50	92	13.4	10.8	2	2
Mean		52.8	66.2	4.9	37	26.6	47.8	75.4	12.8	15.0	3	4.1
Standard Deviation		5.3	33.3	9.3	16.8	16.0	7.9	14.6	1.3	1.4	1.7	2.1

* Presyncope
** Psychological termination
*** Tachycardia > 160

TABLE 6.2

FINAL SCORE TABULATION OF PHYSICAL FITNESS TESTS

(The Subject's Score Expressed as σ from the Mean Score)

Subject	Harvard	Flack	Treadmill	MC-1	Total
A	-0.72	+0.73	-0.30	+0.66	+0.37
B*					
C	-0.56	+0.12	+0.11	+0.72	+0.39
D*					
E	-0.53	-0.04	+0.31	+0.54	+0.28
F*					
G	+0.59	-0.45	+0.86	+1.41	+2.41
H	+1.75	+0.47	-0.16	-0.03	+2.03
I	-0.49	-1.27	-0.71	-0.28	-2.75
J	-0.74	0.00	-0.10	-2.15	-2.99
K	+2.10	+3.34	+2.37	+1.47	+9.28
L	0.00	+0.79	+0.66	-0.28	+1.17
M	-0.51	-0.44	-1.19	-0.09	-2.23
N*					
O	-0.51	-1.01	-1.19	+1.23	-1.48
P	-0.30	+0.92	+0.66	-0.15	+1.13
Q	-2.60	-0.77	-1.47	-0.03	-4.87
R	+0.60	-0.55	+0.52	-0.34	+0.23
S	+0.60	-1.09	+0.93	+0.79	+1.23
T	0.00	-1.00	+1.27	-2.46	-2.19
U	-0.70	-0.20	-0.98	-0.96	-2.84
V	+0.40	+0.86	+0.25	+0.91	+2.42
W	-1.90	-0.20	-1.26	-0.77	-4.13
X	-0.62	-0.17	-0.37	-1.46	-2.62
Y	+1.28	-0.04	-0.37	+0.72	+1.59
Z	+1.43	-0.58	-1.05	+1.04	+0.84
AA	+0.26	-0.04	+1.34	-0.84	+0.72
BB	+0.90	+0.89	+0.72	+1.47	+3.98
CC	-0.20	-0.42	-0.10	-1.15	-1.87
DD	+0.23	+0.15	+1.48	-0.34	+1.52
EE	+1.11	+2.32	+1.14	+0.23	+4.80

* Subjects who terminated tests for psychological reasons

TABLE 6.3

FINAL RANKING OF CANDIDATES ON PHYSICAL FITNESS TESTS

(The Subject's Score Expressed as σ from the Mean Score)

Rank	Subject	Score
1	K	+9.28
2	EE	+4.80
3	BB	+3.98
4	V	+2.42
5	G	+2.41
6	H	+2.03
7	Y	+1.59
8	DD	+1.52
9	S	+1.23
10	L	+1.17
11	P	+1.13
12	Z	+0.84
13	AA	+0.72
14	C	+0.39
15	A	+0.37
16	E	+0.28
17	R	+0.23
18	O	-1.48
19	CC	-1.87
20	T	-2.19
21	M	-2.23
22	X	-2.62
23	I	-2.75
24	U	-2.84
25	J	-2.99
26	W	-4.13
27	Q	-4.87
	B*	
	D*	
	F*	
	N*	

* Subjects who terminated tests for psychological reasons

REFERENCES

6.1. McGuire, T. F. Stress Tolerance Studies, Part I. Unpublished Data. 1958.

6.2. McGuire, T. F. Tolerance to Physical Stress, Part II. Unpublished Data. 1958.

6.3. Balke, B. Correlation of Static and Physical Endurance. Proj. No. 21-32-004. Air University, School of Aviation Medicine, Randolph Air Force Base, Texas. 1952.

6.4. Hale, H. B., et al. Changes in Plasma Corticosteroids and Bicarbonate as a Result of Piloting Supersonic Aircraft. Report 59-61. Air University, School of Aviation Medicine, Randolph Air Force Base, Texas. April 1959.

6.5. Hale, H. B., et al. "Plasma Corticosteroid Levels in Aircrewmen after Long Flights." J. Clin. Endocrin. and Metab. XVIII. 1440-43. December 1958.

6.6. Marchbanks, V. H., Jr., et al. "Effect of Flying Stress on Urinary 17 Hydroxy-corticosteroid Levels: Observations During a 22-1/2 Hour Mission." J. Av. Med. 29: 676-682. September 1958.

6.7. Wiggers, C., et al. "Standardization of Blood Pressure Readings." Am. Heart J. 18: 95-101. July 1939.

6.8. Dermksian, G., and L. Lamb. Cardiac Arrhythmias in Experimental Syncope. Report 59-16. Air University, School of Aviation Medicine, Randolph Air Force Base, Texas. November 1958.

CHAPTER VII

PSYCHOLOGICAL TESTS

G. E. Ruff, Capt., USAF, MC

INTRODUCTION

Because the emotional demands of space flight may be severe, a variety of psychological tests were included in the Project Mercury Candidate Evaluation Program. Criteria for recommendations on each candidate's psychological qualifications were based both on the mission requirements and on a study of behavior under stress conditions analogous to those anticipated during an orbital flight. These requirements suggested that the following general characteristics would be desirable in the pilot of a space vehicle:

1. He should have a high level of intelligence, with abilities to interpret instruments, perceive mathematical relationships, and maintain spatial orientation.

2. He should demonstrate evidence of sufficient drive and creativity to insure positive contributions to the development of the vehicle and other aspects of the project as a whole.

3. He should not be overly dependent on others for the satisfaction of his needs. At the same time, he must be able to accept dependence on others—engineers, ground crews, and the like—when required for the success of the mission. He must be able to tolerate both close associations and extreme isolation.

4. The pilot should be able to function when out of familiar surroundings and when usual patterns of behavior are impossible.

5. He must show evidence of ability to respond predictably to foreseeable situations, without losing the capacity to adapt flexibly to circumstances which cannot be foreseen.

6. His motivation should depend primarily on interest in the mission rather than on exaggerated needs for personal accomplishment.

7. He should not demonstrate evidence of impulsivity. He must act when action is appropriate, but refrain from action when inactivity is appropriate. He must be able to tolerate stressful situations passively without requiring motor activity to dissipate anxiety.

PSYCHOLOGICAL EVALUATION TECHNIQUE

The psychological evaluation included 30 hours of psychiatric interviews, psychological tests, and observations of stressful tests. The information obtained was used to rate candidates in each of 17 categories. Ratings were made on the basis of specific features of behavior, both as indicated by the past history and as observed during the interviews and tests. The 17 categories are:

1. Drive.—An estimate of the total quantity of instinctive energy

2. Freedom from Conflict and Anxiety.—A clinical evaluation of the number and severity of unresolved problem areas and of the extent to which they interfere with the candidate's functioning.

3. Effectiveness of Defenses.—A rating of the efficiency of psychological defenses. It was asked, for example, whether defenses are flexible and adaptive or rigid and inappropriate.

4. Free Energy.—An evaluation of the quantity of neutral energy. An attempt was made to determine whether defenses were so expensive to maintain that nothing is left for creative activity.

5. Identity.—An appraisal of how well the candidate has established a concept of himself and his relationship to the rest of the world

6. Object Relationships.—An estimate of the candidate's capacity to form genuine relationships. Can he withdraw from these when necessary? To what extent is he involved in his relationships with others?

7. Reality Testing.—An evaluation of the degree to which the subject's view of his environment is undistorted. It was also determined if his life experiences had been broad enough to allow a sophisticated appraisal of the world and if his view of the mission represents fantasy or reality.

8. Dependency.—An estimate of how much the candidate must rely on others. How well does he accept dependency needs? Is separation anxiety likely to interfere with his conduct of the mission?

9. Adaptability.—A rating of how well he adapts to changing circumstances. What is the range of conditions under which he can function? What are the adjustments he can make? Can he compromise flexibly?

10. Freedom from Impulsivity.—An evaluation of the candidate's capacity to delay gratification of his needs. This depends partly on whether his behavior in the past has been consistent and predictable.

11. Need for Activity.—An estimate of the minimum degree of motor activity required. Can the candidate tolerate enforced passivity?

12. Somatization.—An estimate of the probability that the candidate will develop physical symptoms while under stress

13. Quantity of Motivation.—An evaluation of how strongly the candidate wishes to participate in the mission. Are there conflicts between motives? Are these conflicts conscious or unconscious? Will his motivation remain at a high level?

14. Quality of Motivation.—A rating of the effectiveness of the candidate's motivation. Is he motivated by a desire for personal gratification? Does he show evidence of self-destructive wishes? Is he attempting to test adolescent fantasies of invulnerability?

15. Frustration Tolerance.—An appraisal of the probable result of failure to reach established goals. What behavior can be expected in the face of annoyances, delays, or disappointments?

16. Social Relationships.—An evaluation of how well the subject works with a group. Does he have significant authority problems? Will he contribute to the success of missions for which he is not chosen as pilot? How well do other candidates like him?

17. Over-all Rating.—An estimate of the subject's suitability for the mission, based upon interviews, test results, and other information considered relevant.

PSYCHOLOGICAL TESTS

Initial evaluations of the candidates were made by two psychiatrists, who carried out separate interviews of each man. Ratings by the psychiatrists were compared, information was pooled, and a combined rating was made. Areas of doubt and disagreement were recorded for subsequent investigation.

The men accepted for the final screening procedure were seen again several weeks later, after an intensive evaluation of their physical status had been completed. Each candidate was reinterviewed and the following psychological tests were administered:

Personality and Motivation:

1. Rorschach Test.—By observing the nature of a subject's associations to 10 ambiguous ink blots, the psychologist is able to probe relatively deep levels of the personality. Important information on emotional conflicts and defense mechanisms can be obtained by analyzing what is seen and how it is seen.

2. Thematic Apperception Test.—The subject is asked to tell stories suggested by a series of pictures. This test yields information about interpersonal relationships on a fairly deep level.

3. Draw-a-Person.—By drawing male and female human figures, the subject gives information on his body image and feelings about his place in the world.

4. Sentence-Completion Test.—This is a series of incomplete sentences which are completed by the subject. His choice of conclusions provides further personality data.

5. Minnesota Multiphasic Personality Inventory.—An objective paper-and-pencil test which offers a description of personality based on responses to a 566-item questionnaire.

6. Gordon Personal Profile.—Information on 5 aspects of personality is obtained by asking the subject to choose, from each of 17 groups of 4 statements, the one which describes him best and the one which describes him least.

7. Edwards Personal Preference Schedule.—The subject must choose one statement from each of 225 pairs of self-descriptive statements. This yields scores representing 12 personality dimensions.

8. Shipley Personal Inventory.—A test involving 20 pairs of self-descriptive statements related to psychosomatic problems

9. Outer-Inner Preferences.—The subject chooses one statement from each of 52 pairs of statements on feelings about activities, things, and other people. This measures interest in and dependency on social groups.

10. Pensacola Z.—By choosing one statement from each of 66 pairs of statements, the subject gives information on "authoritarian" attitudes.

11. Officer Effectiveness Inventory.—A multiple-choice, self-descriptive test of characteristics related to successful officer performance

12. "Who Am I?"—The subject is asked to write 20 answers to the question: "Who am I?" This is interpreted projectively to give information on identity and perception of social roles.

13. Peer Ratings.—Each candidate is asked to indicate which of the other members of the group accompanying him through the program he likes best, which one he would like to accompany him on a two-man mission, and which one he would assign to the mission if he could not go himself.

Intellectual Functions and Special Aptitudes:

1. Wechsler Adult Intelligence Scale.—A relatively objective measure of 11 verbal and performance functions

2. Miller Analogies.—A test of intelligence based on the ability to comprehend analogies

3. Raven Progressive Matrices.—A test of nonverbal concept formation

4. Doppelt Mathematical Reasoning Test.—A test of mathematical aptitudes

5. Engineering Analogies.—A measure of engineering aptitudes and achievement

6. Mechanical Comprehension.—A measure of mechanical aptitudes and ability to apply mechanical principles

7. Air Force Officer Qualification Test.—The portions used are measures of verbal and quantitative aptitudes.

8. Aviation Qualification Test (USN).—A measure of academic achievement

9. Space Memory.—A test of memory for location of objects in space

10. Spatial Orientation.—By testing the speed of locating details in aerial photographs and matching photographs with maps, spatial visualization and orientation are determined.

11. Gottschaldt Hidden Figures.—A measure of ability to locate a specified form imbedded in a mass of irrelevant details

12. Guilford-Zimmerman Spatial Visualization.—A test of ability to visualize movement in space

REACTIONS TO STRESS TESTS

In addition to the interviews and tests, important information was obtained from the reactions of each candidate to a series of stress experiments simulating conditions expected during the mission. Neither the design of these tests nor the physiological variables measured will be discussed. Psychological data were derived from direct observation of behavior, postexperimental interviews, and administration before and after each run of alternate forms of six tests of perceptual and psychomotor functions. These procedures were:

1. Pressure Suit Test.—After dressing in a tight-fitting garment designed to apply pressure to the body during high-altitude flight, each candidate entered a chamber simulating an altitude of 65,000 feet. This produces severe physical discomfort and confinement.

2. Isolation.—Each man was confined to a dark, soundproof room for 3 hours (see figure 7.1). While this brief period is not stressful for most people, data are obtained on the style of adaptation to isolation. This procedure aids in identifying subjects who cannot tolerate enforced inactivity, enclosure in small spaces, or absence of external stimuli.

3. Complex Behavioral Simulator.—The candidate was required to make different responses to each of 14 signals which appeared in random order at increasing rates of speed (see figure 7.2). Since the test produces a maximum of confusion and frustration, it measures ability to organize behavior and to maintain emotional equilibrium under stress.

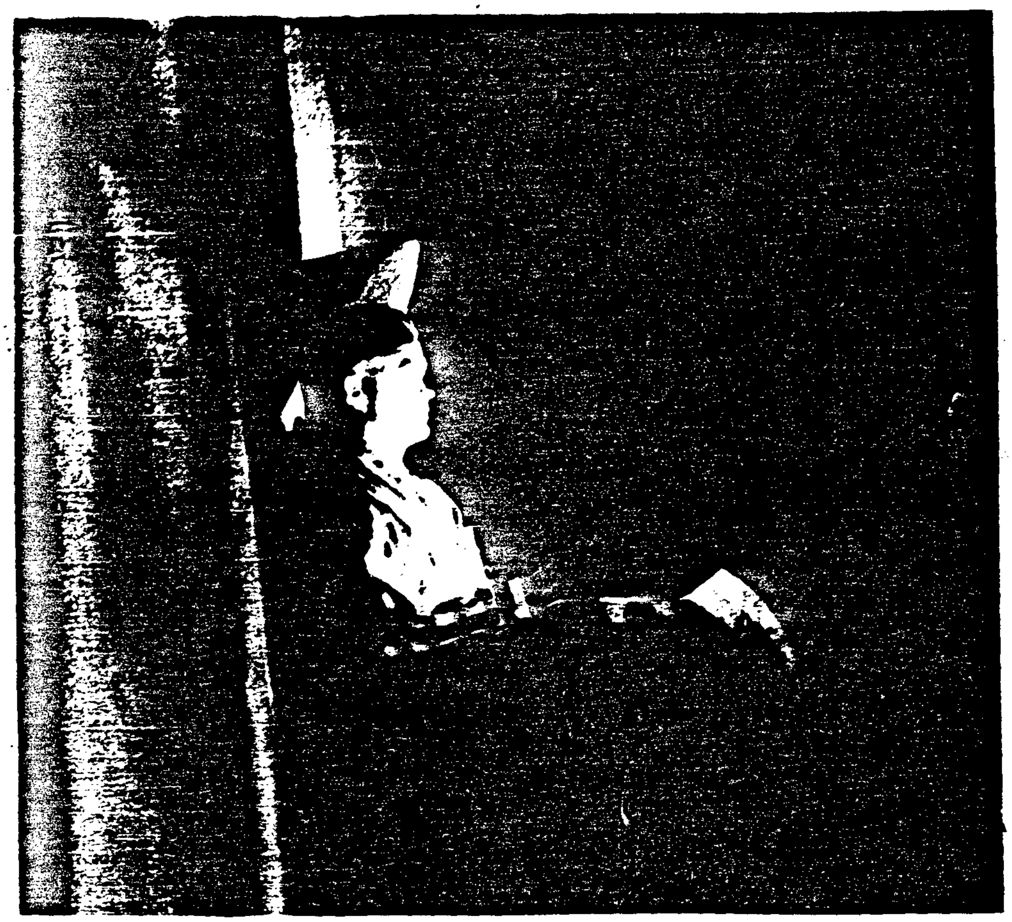


Figure 7.1. Isolation Test. Light on Subject's Face for Photographic Purposes Only

4. Acceleration.—The candidates were placed on the human centrifuge in various positions and subjected to different g-forces. This procedure leads to anxiety, disorientation, and blackout in susceptible subjects.

5. Noise and Vibration.—Candidates were vibrated at varying frequencies and amplitudes and subjected to high-energy sound. Efficiency is often impaired under these conditions.

6. Heat.—Each candidate spent 2 hours in a chamber maintained at 130° F. Once again, this is an uncomfortable experience during which efficiency might be impaired.

FINAL RANKING

After all of the tests were completed, an evaluation of each man was made by a conference of those who had gathered the psychological data. Final ratings were made in each category described previously and special aptitudes were considered. Each candidate was then ranked according to the estimate of his psychological qualifications for the mission.

Figure 7.2. Complex Behavioral Simulator. Observer Stands behind Subject.

CHAPTER VIII

THE CANDIDATE EVALUATION COMMITTEE

The Candidate Evaluation Committee rendered professional interpretation of the biomedical data collected at the Aerospace Medical Laboratory during testing of the candidates. The final objective was to rank and recommend the candidates. The candidates ranked as outstanding were, in the opinion of the Committee, the most desirable team members for Project Mercury. The candidates not recommended were not desirable as members. The remaining candidates were ranked as highly recommended. This means that they were suitable for Project Mercury, but did not demonstrate the characteristics seen in the outstanding group.

ORGANIZATION

Chairman:

The position of chairman was occupied by the Aerospace Medical Laboratory Project Coordinator. He presided at all meetings and established rules of policy.

Secretary:

The position of secretary was filled by the Candidate Evaluation Program Task Officer. His duties consisted of receiving, from each principal investigator, the raw data, mark sense cards, narrative summaries, and other pertinent information derived from the candidates, and then dispersing this information to appropriate agencies for use in the selection of the Mercury Astronauts. He maintained written records of each meeting.

Principal Investigators:

Each unit was represented on the Committee by the principal investigator or his appointed representative. The principal investigator was responsible for preparing: interpretive summaries on each candidate, mark sense cards, and records of test performance.

Assistant Investigators:

Each unit was encouraged to send assistant investigators to the Committee meetings where they contributed to the information and evaluation of the candidates.

PROCEDURE

Weekly Meetings:

A meeting of the Committee was held each week. Once the Committee was assembled, each unit's principal investigator briefed the Committee on the results of each candidate's performance. Prior to the Committee briefing, the investigator and his assistants avoided discussion of the candidate's performance with any other Committee member except in the rare instances where it was medically indicated. Each principal investigator performed a unit ranking of the candidates, based on performance, and each week the unit ranking list incorporated all of the previously tested candidates. When the Committee had been thoroughly briefed on all of the candidates each week, it jointly ranked them.

THE CANDIDATE EVALUATION COMMITTEE

Final Meeting:

The final Committee meeting accomplished two tasks. First, the Committee, ranked all of the candidates on the basis of total performance as it had done each previous week. Second, the Committee rated each of the candidates as outstanding, highly recommended, or not recommended.

In an approach to final candidate recommendations, it was the unanimous opinion of the Committee that candidates, with character traits undesirable in the team effort, should not be recommended. It was the opinion of the Committee that there were eight candidates who should not be recommended for Project Mercury because they demonstrated a lack of the attributes necessary in the team effort of Project Mercury.

The remainder of the candidates (23) were divided into outstanding or highly recommended. Those who were chosen as outstanding candidates demonstrated excellence in maturity, intelligence, motivation, and emotional stability. It was desirable but not mandatory that they also demonstrated excellence in physiological performance to the stressful tests which were given throughout the Aerospace Medical Laboratory. The candidates ranked as highly recommended performed in a highly satisfactory manner and were seemingly adequate for Project Mercury. But on the basis of competitive performance they had not attained that degree of excellence which had been demonstrated by those rated as outstanding. Seven candidates were recommended as outstanding, without reservations. Three additional candidates were recommended as outstanding with reservations. The reasons for reservations were:

1. One candidate was not entirely sure that he desired to continue on in Project Mercury.

2. One candidate had a heart murmur of probable organic etiology.

3. One candidate had a very high index of strain as a result of his performance on the heat test.

The purpose of the reservations was to bring these problems to the attention of the NASA selection team.

There were 13 candidates who were highly recommended. Table 8.1 is a summary of the ranking of all of the candidates by each unit. Table 8.2 lists the Committee's final recommendations.

The candidates chosen as Mercury Astronauts by the National Aeronautics and Space Administration were: G, K, R, S, U, Z, EE. All but one of the candidates recommended as outstanding by the Committee were chosen as Mercury Astronauts.

TABLE 8.1

FINAL RANKING OF CANDIDATES

UNIT RANKING

Acceleration	Biological Acoustics Noise	Biological Acoustics Vibration	Heat	Physical Fitness	Psychology
DD	D	J	G	K	EE
G	V	H	P	EE	R
J	E	B	Q	BB	Z
R	S	Q	U	V	DD
M	BB	EE	DD	G	K
K	G	U	I	H	CC
O	P	F	E	Y	L
F	Q	A	H	DD	G
V	I	C	V	S	Q
D	U	V	AA	L	U
X	AA	P	S	P	J
U	B	BB	L	Z	E
H	A	G	K	AA	O
P	R	L	C	C	BB
EE	CC	X	A	A	S
BB	C	W	N	E	W
S	Y	CC	BB	R	Y
AA	J	K	CC	O	AA
E	DD	S	EE	CC	B
Z	T	T	Z	T	P
W	X	DD	F	M	X
L	L	D	D	X	I
Y	K	Y	M	I	A
T	EE	M	B	U	C
C	N	Z	J	J	M
A	M	R	Y	W	V
B	O	I	O	Q	N
N	H	O	R	B	H
Q	W	AA	W	D	D
CC	Z	E	T	F	T
I	F	N	X	N	F

TABLE 8.2

FINAL RECOMMENDATIONS

Outstanding Without Reservations	Outstanding With Reservations	Highly Recommended	Not Recommended
G	R	A	B
L	V	C	D
K	DD	E	F
S		J	H
U		M	I
Z		O	N
EE		P	T
		Q	X
		W	
		Y	
		AA	
		BB	
		CC	

CHAPTER IX

DATA PROCESSING CORRELATION STUDIES

C. L. Wilson, Capt., USAF, MC

TECHNIQUE

Whenever a test was given to a candidate, raw data were gathered. In some instances, the performance data could be expressed as one numerical value (for example, the positive g before blackout). More frequently, the performance data formed a lengthy list of components (for example, pulses, blood pressures, biochemical values, and subjective comments). Some of these components were rendered into a final score, not always a reflection of all of the component bits of information.

For example, the components of performance of the partial pressure suit test are:

1. P_r = 83
2. P_t = 144
3. Test abort due to presyncope
4. Test abort due to tachycardia
5. Test abort for psychological reasons
6. Duration at 65,000 feet
7. Previous pressure suit experience
8. Pretest urinary catacholamine
9. Posttest urinary catacholamine
10. Pretest plasma steroid
11. Posttest plasma steroid
12. Pretest 3-methoxy-4-hydroxymandelic acid
13. Posttest 3-methoxy-4-hydroxymandelic acid

The final MC-1 score only reflected the pulse change during the test. The score was $S_{mc-1} = P_t - P_r = 61$. Thus, the final score did not reflect all of the component bits of data gathered during the test.

MARK SENSE CARD

It became apparent that a great portion of the component data could not conveniently be incorporated into the final test score. It was desirable that these components in some way be recorded and correlated with one another to determine the existence or nonexistence of any significant relationships. For example, it would be valuable to demonstrate if there is a significant correlation between an increasing A-P diameter of the chest by anthropometric measurement and an increasing ability to breathe more normally at 8 forward g's. It would also be valuable to know if those chosen as Astronauts demonstrated performance significantly different from the non-Astronauts.

It was possible to record these test components on a mark sense card.* Figure 9.1 shows an example of the mark sense cards which were developed for the MC-1 partial pressure suit test. The data on the example card was extracted from the MC-1 test example.

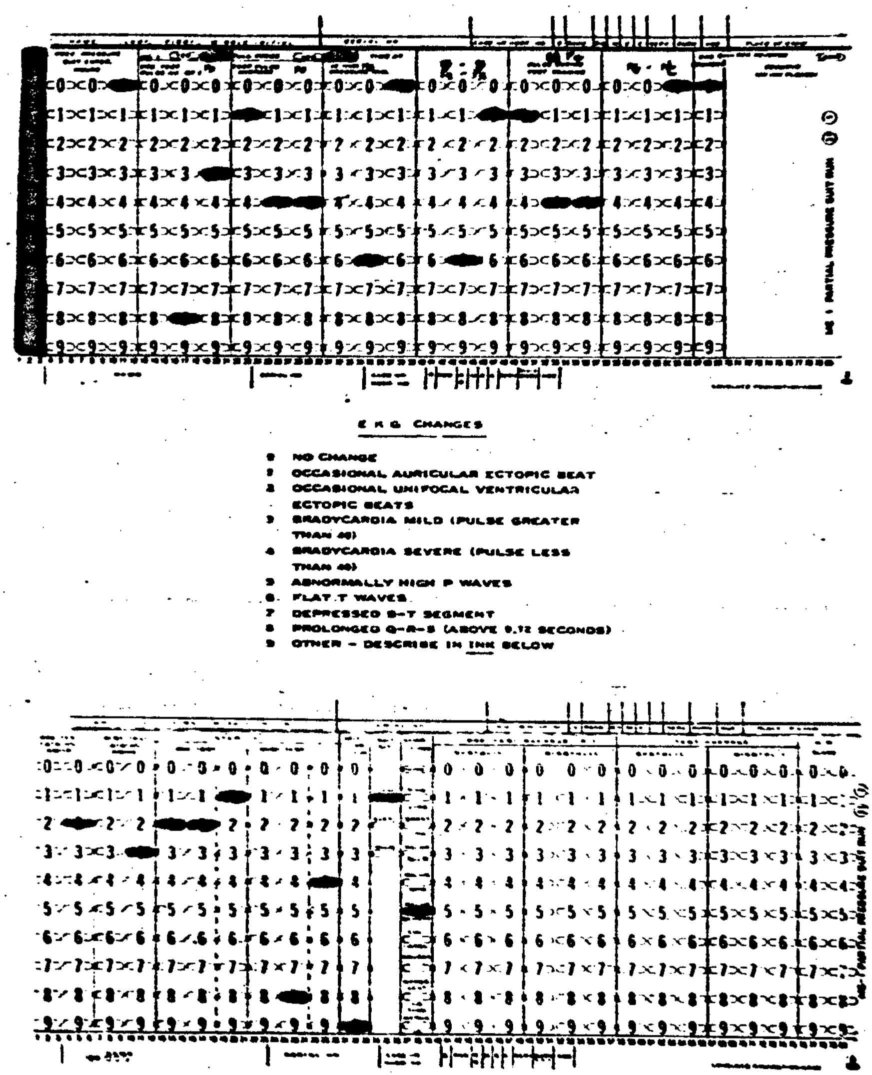


Figure 9.1. Example of Mark Sense Card for MC-1 Partial Pressure Suit Test

* Valuable advice on the application of this mark sense card came from A. H. Schwichtenberg, Brig. General, USAF, MC (Ret.), Head, Department of Aviation and Space Medicine, Lovelace Foundation, Albuquerque, New Mexico. Dr. Schwichtenberg also expedited the development of appropriate cards for each test given at the Aerospace Medical Laboratory.

The marked card is later processed in a mark sensing machine.* These cards must also be identified as to subject, card number, and test. This can easily be done by punch holes. When the card is complete it will have the subject's identity, test, and component data.

VARIABLES FOR CORRELATION

Each testing section was queried as to what components (variables) it wished to submit for correlation studies. Appendix IV lists those variables. There were 104 of them to be correlated.

QUESTIONS TO BE ANSWERED

Once the data had been collected, reduced, and the component information placed on punch cards, it became feasible to program specific correlation trials which the card processor could perform. All answers were expressed as correlation coefficients.

When a correlation coefficient is other than zero, an apparent relationship exists between the two variables. When an apparent relationship exists between variables A and B it may mean one of the following:

1. That there is a cause and effect relationship.

2. That there is a denominator common to A and B.

3. That there is no actual relationship between A and B, but that the apparent relationship was due to chance in sampling.

The correlation coefficient is expressed as r. In sampling of 31 subjects from a universe, if r is greater than 0.449, then one may be at least 99% confident that any relationship which apparently exists is not due to chance. If r is greater than 0.8000 then one may infer that the relationship which exists is very probably real. If r is less than 0.2000 then it is highly probable that the components are not actually related by cause and effect or a common denominator. When a minus sign precedes r, an apparent negative correlation exists.

EXAMPLE OF INTERPRETATION

Component 16 compared with component 17 has a high r value of 0.8909. It appears that the total I.Q. and the verbal I.Q. are significantly related. This interpretation appeals to reason.

Component 16 compared with component 101 has an r value of 0.5150. While it is conceivable that a real relationship between I.Q. and milliliters of oxygen/pulse could exist, it is more reasonable to conclude that no real significance exists, and that the apparent cause for relationship is not obvious.

Appendix IV demonstrates that there are approximately 250 r values greater than 0.449. The reader must judge for himself which variables are significantly related. Often where there are high

---

* The data processing was accomplished through an existing contract with the University of Dayton. Miss Theresa A. Fricke, statistical consultant, contributed greatly to the final data processing and calculation of correlation coefficients.

r values (above 0.8000), the two variables are measurements of the same or nearly the same test. Examples are: 16 and 17, 51 and 53, 65 and 102, 73 and 83, and 94 and 95.

In addition to determining the significant correlations between various tests, it was valuable to know if there was a difference between the performance of the Astronauts and the non-Astronauts. This was determined by a statistical analysis (see Appendix V).

To test whether the variability of the test performance among the Astronauts is the same as the variability among the non-Astronauts, the ratio of the variances (S^2) of the two groups is used. This ratio is taken such that the larger S^2 is in the numerator. The ratio is compared with the critical F statistic. If the computed ratio exceeds the critical F statistic of 3.71 (with S^2 of the numerator based on 7 observations and S^2 of the denominator based on 24) or the critical F statistic of 7.33 (with S^2 of the numerator based on 24 observations, S^2 of the denominator based on 7) then the two variances are significantly different from one another at the 99% confidence level. The following tests show the significant differences in variability between the two groups:

Test	$\bar{X}_A$	$\bar{X}_N$	S^2_A	S^2_N	F
36	39.0	37.5	24.00	302.69	12.61
86	787.1	626.1	287057.18	50943.43	5.63
94	6.0	9.3	3.33	32.25	9.68
100	191.4	176.1	1407.03	322.65	4.36
103	54.7	57.9	20.41	227.17	11.13

$\bar{X}_A$ = Mean Astronaut Score S^2_A = Astronaut Variance
$\bar{X}_N$ = Mean Non-Astronaut Score S^2_N = Non-Astronaut Variance
F Represents the Ratio of the Variances

To test whether the mean test result of the Astronauts is significantly different from the mean result for non-Astronauts, the difference between these two means is examined in relation to the variance of the means. In other words, the difference is examined in the light of how well that difference can be reproduced. This is done by means of the t statistic (t represents the probability of statistical difference).

$$t = \frac{\bar{X}_A - \bar{X}_N}{\sqrt{\frac{6S^2_A + 23S^2_N}{29}\left(\frac{1}{7} + \frac{1}{24}\right)}}$$

The 99% critical value of t with variance based on 29 observations is 2.756. Only two tests exceeded this value:

Test	$\bar{X}_A$	$\bar{X}_N$	S^2_A	S^2_N	F	t
1	7.6	6.5	0.36	0.78	2.16	3.0
22	15.7	13.8	1.08	2.69	2.49	2.8

It may be concluded that the Astronaut performance was significantly different from the non-Astronauts on only two tests, both psychological—1 (Total Psychological Score) and 22 (Similarities in WAIS, Wechsler Adult Intelligence).

CHAPTER X

DISCUSSION AND RECOMMENDATIONS

Thirty-one highly selected adult males were the subjects of a crew recommendation study. Data were gathered from the performance of each subject on each test. One hundred and four performance variables were correlated. The following statements represent preliminary impressions from this Project Mercury Candidate Evaluation Program. It is recognized that the investigators were studying a small, highly selected population. Therefore, it is difficult to render conclusions on statistical significance.

1. Psychological stability is the most important consideration in evaluating a candidate. The intelligence, maturity, and motivation of a candidate are vital areas to be assessed before rendering a recommendation.

2. Excellent physiological performance was a secondary consideration in the final Committee recommendations.

3. The main value of a severely stressful physiological test was the interpretation of the psychological response to that stress test. Whenever a subject terminated a severe test for psychological reasons, he was not recommended by the Committee.

4. It is possible to eliminate subjects by use of stressful tests. It is not presently possible to select subjects with confidence, where selection is based entirely upon their excellent physiological performances.

5. No single, nonsimulating test has been identified which will be of great assistance in recommending crew members. A large battery of tests, such as were performed, lends confidence to the final recommendations.

6. Whenever a candidate is being considered for a special mission, it is desirable that a large number of trained observers each have the opportunity to test him and to render an opinion before the final recommendation.

7. This study has demonstrated that there is no statistically significant difference in the physiological or biochemical responses of the Mercury Astronauts when compared with the remainder of the NASA candidates.

8. There is no evidence to support a thesis which maintains that visual inspection, biochemical measurements, or physiological responses of a candidate are of principal value in rendering a reliable recommendation of suitable candidates. These are secondary considerations.

9. While the hormones and their metabolites are valuable research tools, this study has demonstrated that they were not significantly different in the Mercury Astronauts when compared with the remaining NASA candidates.

10. There is every reason to suspect that safe, standardized, moderately stressful and severely stressful tests (such as having the subject walk on the treadmill until he voluntarily terminates) would be of great assistance in future crew recommendation programs, since severe stress also tests the candidate's motivation.

11. It is believed that testing of those who did not volunteer as candidates would be valuable, since the nonvolunteer group might lack the same intensity of motivation which was possed by the volunteers.

APPENDIX I

MEDICAL EVALUATIONS
PERFORMED AT THE LOVELACE FOUNDATION

SCHEDULE I. LABORATORY TESTS

Cholesterol
Differential
Hemoglobin
Leucocytes
Hematocrit
Blood Grouping
RH Factor
Serology
Sedimentation Rate
Liver Function Test (BSP)
Sperm Count
Throat Culture and Smear
Smear of Nasal Mucosa
Serum Protein-Bound Iodine
Special Hematology Smear
Blood Sugar
Stool Examinations for Ova and Parasites
Urinalysis
Gastric Analysis
Electrocardiogram with Master 2-Step
Ballistocardiogram
Electroencephalogram
24-Hour Urinary 17-Ketosteroid Excretion
Electrolyte Studies
Catacholamines Urinary
Urea Clearance
Protein Electrophoresis

SCHEDULE II. X-RAY EXAMINATIONS

Chest - P-A during Inspiration, P-A during Expiration, Right Lateral of Chest
Colon - Barium Enema (High kv. Technique Used for Compression Spot Films; Image Intensifier Used for Fluoroscopy)
Sinuses
Lumbosacral Spine - A-P and Lateral (Obliques when Indicated)
Stomach and Esophagus - (Image Intensifier Used for Fluoroscopy)
Teeth

SCHEDULE III. OPHTHALMOLOGY

History and Examination including Dilation, Visual Fields, Tonometry, Slit Lamp Studies, Dynamic Visual Acuity, and Depth Perception Test
Dark Room Examination
Photography of Conjunctival Vessel and Retina

SCHEDULE IV. OTOLARYNGOLOGY

Examination, Indirect Laryngoscopy, and Nasopharyngoscopy
Audiogram and Audiogram with Background Noise
Speech Discrimination Test and Tape Recording of Voice
Labyrinthine Sensitivity Studies - Caloric Test

SCHEDULE V. SPECIAL PHYSIOLOGICAL EXAMINATIONS

Bicycle Ergometer Test
Pulmonary Function Tests - Vital Capacity and Maximum Breathing Capacity
Total Body Radiation Count - Performed by Los Alamos Scientific Laboratory
K^{40} Method of Determination of Lean-Body Mass - Performed by Los Alamos Scientific Laboratory
Specific Gravity of Whole Body
Blood Volume and Total Circulating Hemoglobin
Total Body Water Determination

SCHEDULE VI. CARDIOLOGY

Examination by Cardiologist
Special Vectorcardiogram
Phonocardiogram

SCHEDULE VII.

Complete Medical History with Special Questions on Aviation Experience

APPENDIX II

MODIFICATIONS OF PHYSICAL FITNESS TESTS

Harvard Step Test:

1. All subjects will be provided with tennis shoes since testing in stocking feet may produce blisters or hematomas.

2. All subjects must try to continue to perform for 5 minutes on the Harvard step test. Even if their pace slacks to a very slow speed, they shall be encouraged. If they voluntarily quit (none of them did), this shall be recorded. The number of steps-up will be counted on a mechanical counter. The main reason for this change is that it would be impossible to reschedule the subject for a future step test. Another reason for encouraging the candidate to continue for 5 minutes is to give the observer a chance to see and describe the subject's coordination, motivation, and physical stamina. Such observations greatly assist the investigators in their narrative summaries.

Flack Test:

Only the length of time that the subject maintained the column of mercury at 40 mm. Hg was recorded. Since the test is of questionable value, it was decided to use the most promising measurement. Powell and Sunahara[II.1] report extensively on this test.

Cold Pressor Test:

No changes were made in the administration of this test. These subjects did not know about this test until the moment they were confronted with ice water. It is very interesting and probably significant that the coinvestigators independently decided that all subjects should be able to keep their feet in the ice water for the 7 minutes. Those who withdrew their feet were probably less motivated, probably uncooperative. Having made this decision, they then read McGuire's interpretation[II.2] which is identical. The coinvestigators declined further interpretation of the cold pressor test. Here was an excellent opportunity to correlate a physiological reaction with the Mercury Astronaut population and with other tests performed throughout the laboratory. Since the Mercury Astronauts were chosen with no consideration for physiological responses to the cold pressor test, there would be no previously existing relationship.

MC-1 Test:

Several changes were incorporated into this test:

1. The feet were not wrapped with ace bandage. Abundant evidence (Wilson and Zinn[II.3]) shows no MC-1 terminations because of foot discomfort. No NASA subject complained of foot discomfort when wearing regular oxford shoes during the test. In the past an occasional test would be aborted because of ischemia caused by the ace bandage being too tight.

2. Blood pressures were not recorded. The errors inherent in the strain gauge method and the delays so frequently encountered in balancing the strain gauge rendered it impractical. When a reliable method is available, it will be of great value.

3. The precordial leads were not used. Detailed analysis of previous precordial and standard EKG tracings demonstrates that sufficient information for analysis is available in the standard leads.

4. The MA-2 helmet was used in lieu of the short neckseal K-1. The purpose was twofold. The neckseal of the K-1 helmet was a frequent cause of MC-1 pressure suit test abortions. Often the K-1 neckseal leaked dangerously, lowered the bladder and helmet pressures to hypoxic levels in 5% of McGuire's cases. Also, the K-1 helmets were sufficiently uncomfortable to cause test abortion in 7% of McGuire's cases.[II.4] Since these NASA subjects were only available for one test, and since the endpoint of testing was intended to be either physiological or psychological, a more reliable and comfortable helmet was chosen. The MA-2 helmet met the requirements. A secondary reason was to determine the percent of presyncopic terminations in pilot populations wearing these two different helmets. McGuire[II.2] reasons that at least part of the episodes of syncope or presyncope (vide infra) could be due to carotid body or common carotid artery pressure. This argument has some merit since the poor counterpressurizing neck of the helmet does cause locally higher capillary pressure which effects a transfer of more fluid into the cells and interstitial spaces. Wilson and Zinn[II.3] had described actual extra-arterial occlusion subsequent to poor counterpressurization. If McGuire's series of a similar pilot population wearing the K-1 helmet experienced greater frequency of presyncope or syncope than the NASA candidate population, then further evidence to support the thesis that the poor neck counterpressurization of the K-1 helmet was in part responsible for cases of syncope.

5. There were no other departures from the MC-1 test profile. The program was strictly adhered to in every case. The endpoints for termination were those recommended by a joint agreement of McGuire, Leary, and Wilson (vide infra).

6. The scoring system was changed. The coinvestigators agreed with McGuire's thesis that an average test pulse, which is unchanged or only slightly higher than an average pretest resting pulse, is desirable. This element was retained in the scoring. The coinvestigators reasoned that psychological terminations should be separated from physiological terminations. The coinvestigators did not recommend any candidate who terminated the MC-1 test for psychological reasons.

Wilson and Zinn[II.3] reported that a sizable portion of different pilot populations (13% to 21%) have experienced presyncope or unconsciousness during the MC-1 test. There is no totally rational reason to eliminate a candidate because he becomes presyncopic during the test. In an attempt to perform an unbiased correlation between the development of presyncope and the selection of Mercury Astronauts, no interpretation was made of the episode of presyncope. Tachycardia (one case) was handled in an identical manner (vide infra).

<u>Tilt Table Test:</u>

Two minor variations were made in this test. Immediately after the subject terminated the 3-minute Harvard step test, he stood on the tilt table which was preset at 65°. Thus, the long axis of the subject's body was 65° above the horizontal and the head was elevated. An assistant secured the shoulder braces while the investigator placed the blood pressure cuff on the subject's right arm. This took 30 seconds. Thus, it was possible to obtain a pulse and blood pressure during the first minute following the exercise. When the subject is directed to stand on the tilt table immediately after exercise (rather than rest on the horizontal for 2 minutes) there is less opportunity to compensate physiologically. Nausea, vomiting, and/or hypotension sufficient to terminate were evoked in three candidates during the first 5 minutes of standing on the tilt table. A second modification was the use of a transistorized transmitter* to convey pulse beats to a receiver. This ingenious radio broadcast was used to cross-check the accuracy of auscultatory measurements of test pulses, and to experiment with use of the transmitter during other physical exercise tests. The technique of scoring was modified. There are innumerable ways to express the subject's responses to this test. The scoring system adapted by the coinvestigators has the advantage of reflecting not only the

* This transistorized transmitter was designed and built by Dr. Adolph Mark of the Bioelectronics Section, Aerospace Medical Laboratory.

existence of hypotension, but also how long it remains. It also reflects a tachycardia and how great and how long it is. It is conceivable that even this scoring system will be proved to be inadequate.

Pulse Posture Test Technique:

A test similar to this was performed at the Lovelace Clinic. It was not necessary to duplicate this at the Aerospace Medical Laboratory.

Valsalva EKG:

This test was not performed. It was originally hoped that an expert in the administration of this test would be available. Expert supervision is needed since the test is potentially dangerous. Dermksian and Lamb[II.5] reported 4 cases of cardiac arrest using a similar test. A shortage of medical specialists rendered it impossible to supply the medical staffing necessary to perform this test.

Mecholyl Test:

This test, although initially considered, was not performed on the NASA candidates. In a trial Mecholyl test, the subject suffered severe hypotension BP (96/44, 86/34, 86/50, 88/48 at various minutes), salivation of 500 cc., marked nausea, rhinorrhea, severe and frightening asthma, and near collapse. There was no bradycardia. The subject alway has been in excellent health and is presently on flying status. He never had experienced asthma and there was no familial allergic history. The coinvestigators strongly urge that this test be dropped from consideration for crew selection testing. More suitable tests—such as the measurement of adrenalcortical and medullary hormones or their metabolic byproducts were substituted.

Pressure Breathing Test:

This test was recommended by McGuire but not performed. It is agreed that this may be a valuable test, such as the MC-1 appears to be. The only reasons for excluding it were: it was similar in stress to the MC-1 test and both could not be scheduled. The experience of Capt. C.L. Wilson, physical fitness tests principal investigator, agrees with McGuire's that there are some interesting physiological and psychological responses. It is recommended that this test be considered for future programs.

REFERENCES

II.1. Powell, T. J., and F. A. Sunahara. "A Physiologic Evaluation of the Flack Test." J. Av. Med. 29: 444-453. June 1958.

II.2. McGuire, T. F. Stress Tolerance Studies, Part I. Unpublished Data. 1958.

II.3. Wilson, C. L., and M. B. Zinn. "Medical Problems Associated with High-Altitude Suit Testing." J. Av. Med. (Submitted for Publication in May 1959)

II.4. McGuire, T. F. Time-Altitude Capabilities of the MC-1 Partial Pressure Suit Ensemble. WADC TN 55-734. Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. December 1955.

II.5. Dermksian, G., and L. Lamb. Cardiac Arrhythmias in Experimental Syncope. Report 59-16. Air University, School of Aviation Medicine, Randolph Air Force Base, Texas. November 1958.

APPENDIX III

CODING OF VARIABLES

PSYCHOLOGICAL

1. Over-all Rating of Candidate
2. Drive
3. Freedom from Conflict Anxiety
4. Effective Defense
5. Free Energy
6. Identity
7. Object Relationships
8. Reality Testing
9. Motivation Quantity
10. Motivation Quality
11. Adaptability
12. Social Relationships
13. Freedom from Dependency
14. Freedom from Need for Activity
15. Freedom from Impulsitivity

Wechsler Adult Intelligence Scale:

16. I.Q. Total
17. I.Q. Verbal
18. I.Q. Performance
19. Information
20. Comprehension
21. Arithmetic
22. Similarities
23. Digit Span
24. Vocabulary
25. Digit Symbol
26. Picture Completion
27. Block Design
28. Picture Arrangement
29. Object Assembly

Minnesota Multiphasic Personality Inventory:

30. Hysteria
31. Depression
32. Hypochondria
33. Psychopathic Deviate

Rorsbhach Test:

34. Total Responses (R)
35. Percent Good Form (F + %)
36. Percent Pure Form (F%)
37. Percent Animal Responses (A%)
38. Number of Popular Responses (P)
39. Number of Human Movement Responses (M)

Rorschach Test (continued):

40. Number of Whole Responses (W)
41. Number of Blank Space Responses (S)
42. Weighted Score of Color Responses $\left(\frac{FC + 2CF + 3C}{2}\right)$
43. Inanimate Movement (Fm + m)
44. Animal Movement (FM)
45. Shade Responses (Fc + c)
46. Percent Responses on Color Cards $\left(\frac{VIII - X}{R}\%\right)$
47. Sexual Responses (Sex)
48. Anatomy (At.)

ACCELERATION

49. Decrease in Vital Capacity at 5 g's Positive
50. Decrease in Vital Capacity at 5 g's Flat
51. Decrease in Vital Capacity at 8 g's Flat
52. Decrease in Vital Capacity at 5 g's Tilted
53. Decrease in Vital Capacity at 8 g's Tilted
54. Decrease in Vital Capacity at 12 g's Tilted
55. Blackout Level - Positive g's
56. Increase in Pulse Rate during Positive g

ANTHPOPOMETRIC

57. Cervicale Height *
58. Transverse Diameter of Chest
59. Transverse Diameter of Waist
60. A-P Diameter of Chest
61. A-P Diameter of Waist
62. Chest Circumference
63. Suprasternal Notch to the Waist
64. Cervicale to the Waist
65. Lean-Body Weight
66. Sitting Height/Stature
67. Trochanteric Height/Stature
68. Chest Depth/Chest Breadth
69. Waist Depth/Waist Breadth
70. Hip Breadth/Chest Breadth
71. Height/$\sqrt[3]{wt.}$
72. Somatotype*
73. Present Weight
74. Stature

* This measurement was incorrectly correlated and should be disregarded.

BIOLOGICAL ACOUSTICAL

75. Percent Intelligibility
76. Deviation Score (Amount during Pitch and Roll)
77. Addition Test Scores ($Q_1 + Q_2 + N$) Equals Total Addition Problems Completed
78. $Q_1 + Q_2 - 2N + 3$ Equals Final Noise Score

HEAT VARIABLES

79. Pulse
80. Systolic Blood Pressure
81. Diastolic Blood Pressure
82. Weight Body Temperature
83. Total Body Weight

PHYSICAL FITNESS

84. Tilt Table Test Score
85. Harvard Step Test Score
86. Flack Test Score
87. Valsalva Overshoot Test Score
88. Treadmill Test Score
89. Cold Pressor Test Score
90. MC-1 Partial Pressure Suit Score
91. Partial Pressure Suit Run (EKG Changes)
92. MC-1 Final Test Score
93. Catacholamine (Pre-MC-1 Test)
94. Catacholamine (Post-MC-1 Test)
95. Catacholamine Rise during MC-1 Test
96. Conjugated Hydrocortisone Pre-MC-1 Test
97. Conjugated Hydrocortisone Post-MC-1 Test
98. Conjugated Hydrocortisone Rise during MC-1 Test

LOVELACE FOUNDATION

99. Vital Capacity
100. Maximum Breathing Capacity
101. Milliliters Oxygen/Pulse
102. Lean-Body Mass
103. Protein-Bound Iodine
104. Resting Urine Sample Catacholamine

APPENDIX IV

TABLE OF CORRELATION COEFFICIENTS ON 104 VARIABLES

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
1	1	10000	1	52	328	1	103	1043	2	50	123*	2	101	3681
1	2	6328	1	53	1147	1	104	762*	2	51	761	2	102	5120
1	3	7796	1	54	677				2	52	640	2	103	1421
1	4	7999	1	55	1253	2	2	10000	2	53	1424	2	104	3261
1	5	7636	1	56	2119*	2	3	2642	2	54	633			
1	6	6353	1	57	1098	2	4	5150	2	55	1469	3	3	10000
1	7	6436	1	58	3228	2	5	7840	2	56	1610*	3	4	6445
1	8	7554	1	59	2648	2	6	1136	2	57	3328	3	5	5994
1	9	6670	1	60	487*	2	7	2265	2	58	3313	3	6	6813
1	10	6251	1	61	61	2	8	4650	2	59	2472	3	7	5334
1	11	6962	1	62	2743	2	9	6244	2	60	68	3	8	4792
1	12	6590	1	63	1263*	2	10	6430	2	61	26*	3	9	5159
1	13	4197	1	64	1101*	2	11	4881	2	62	2747	3	10	4491
1	14	4174	1	65	3461	2	12	4851	2	63	325	3	11	5072
1	15	6311	1	66	254*	2	13	532	2	64	331	3	12	5238
1	16	3590	1	67	1844	2	14	595*	2	65	3688	3	13	2884
1	17	3814	1	68	3321*	2	15	3529	2	66	2086*	3	14	-4597
1	18	1953	1	69	2122*	2	16	3456	2	67	2913	3	15	5421
1	19	860*	1	70	27	2	17	3508	2	68	2790*	3	16	~~1126~~
1	20	4553	1	71	2578*	2	18	2077	2	69	2067*	3	17	1382
1	21	1705	1	72	1965	2	19	2125	2	70	1976*	3	18	362
1	22	3030	1	73	3895	2	20	3919	2	71	45	3	19	3498*
1	23	3014	1	74	1444	2	21	814	2	72	95	3	20	1921
1	24	3186	1	75	1137*	2	22	3333	2	73	3146	3	21	576*
1	25	647	1	76	2290	2	23	3620	2	74	3270	3	22	1026
1	26	1269	1	77	1613	2	24	1834	2	75	129	3	23	3391
1	27	510	1	78	577	2	25	2823	2	76	494	3	24	3160
1	28	62*	1	79	1862*	2	26	737	2	77	2198	3	25	340*
1	29	1469	1	80	101	2	27	343*	2	78	1094	3	26	1274*
1	30	3307*	1	81	654*	2	28	865	2	79	299*	3	27	1126
1	31	2567*	1	82	1351*	2	29	657	2	80	378*	3	28	376
1	32	1853*	1	83	4108	2	30	2303*	2	81	1139	3	29	346
1	33	833*	1	84	2520*	2	31	1700	2	82	330*	3	30	3029*
1	34	1042	1	85	1498	2	32	3157*	2	83	3232	3	31	3970*
1	35	3195	1	86	2822	2	33	885*	2	84	1118*	3	32	342*
1	36	894	1	87	839	2	34	1547	2	85	2858	3	33	318*
1	37	107	1	88	2662	2	35	116	2	86	4014	3	34	798*
1	38	586*	1	89	2500*	2	36	446*	2	87	2417	3	35	4954
1	39	1622	1	90	1648	2	37	1051*	2	88	3844	3	36	954
1	40	3729	1	91	1356*	2	38	2236*	2	89	1275	3	37	342
1	41	1081*	1	92	403*	2	39	1123	2	90	1509	3	38	1335*
1	42	1054	1	93	2322*	2	40	2586	2	91	365*	3	39	1149
1	43	385	1	94	1410*	2	41	121*	2	92	45	3	40	744
1	44	2167	1	95	2375*	2	42	2433	2	93	2572*	3	41	1528*
1	45	26	1	96	1679*	2	43	43*	2	94	918*	3	42	2990*
1	46	874	1	97	1373*	2	44	1451	2	95	2848*	3	43	696
1	47	741	1	98	477*	2	45	2456	2	96	1383	3	44	1766
1	48	2399	1	99	1662	2	46	1028	2	97	829	3	45	1245*
1	49	2760	1	100	1554	2	47	738*	2	98	647*	3	46	1059
1	50	2124*	1	101	2497	2	48	1218	2	99	377*	3	47	1807
1	51	99	1	102	4339	2	49	4007	2	100	2251	3	48	1496

*Designates a minus value

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
3	49	1378	3	103	147*	4	55	197	5	8	4903	5	62	3197
3	50	2570*	3	104	1932	4	56	1715*	5	9	6374	5	63	1217
3	51	331				4	57	1971	5	10	6199	5	64	78
3	52	194	4	4	10000	4	58	4221	5	11	5622	5	65	3437
3	53	1722	4	5	6125	4	59	4731	5	12	4159	5	66	690*
3	54	1370	4	6	7247	4	60	1086	5	13	1434	5	67	2130
3	55	1274*	4	7	6606	4	61	1374	5	14	1067	5	68	3560*
3	56	1017*	4	8	6561	4	62	4509	5	15	4832	5	69	2375*
3	57	58	4	9	5059	4	63	321	5	16	3725	5	70	1879*
3	58	2456	4	10	6243	4	64	269*	5	17	3697	5	71	746*
3	59	2524	4	11	8297	4	65	4230	5	18	2530	5	72	769
3	60	886*	4	12	6520	4	66	1409	5	19	429	5	73	3374
3	61	646	4	13	5224	4	67	74*	5	20	4457	5	74	2389
3	62	1820	4	14	4761	4	68	3070*	5	21	674	5	75	666*
3	63	1823*	4	15	6372	4	69	2160*	5	22	4098	5	76	789
3	64	3133*	4	16	3480	4	70	376	5	23	3324	5	77	3320
3	65	1601	4	17	3688	4	71	3153*	5	24	3420	5	78	757*
3	66	314	4	18	1878	4	72	2531	5	25	2280	5	79	272*
3	67	1140	4	19	63*	4	73	5505	5	26	377	5	80	164
[illegible]	68	2876*	4	20	3935	4	74	1879	5	27	1598	5	81	99*
3	69	1267*	4	21	2328	4	75	1520*	5	28	2195	5	82	434*
3	70	554	4	22	1265	4	76	1825	5	29	550	5	83	3325
3	71	2770*	4	23	3519	4	77	1117	5	30	2570*	5	84	11*
3	72	3439	4	24	2829	4	78	1524*	5	31	735*	5	85	1705
3	73	2426	4	25	1072	4	79	3010*	5	32	2579*	5	86	4446
3	74	222	4	26	31*	4	80	1776*	5	33	189*	5	87	1398
3	75	2052*	4	27	683	4	81	272*	5	34	2012	5	88	2831
3	76	712	4	28	905*	4	82	1938*	5	35	1019	5	89	507*
3	77	1266	4	29	1064	4	83	5620	5	36	171*	5	90	2522
3	78	1207*	4	30	1509*	4	84	2012*	5	37	846	5	91	2693*
3	79	1373*	4	31	2912*	4	85	665*	5	38	1813*	5	92	1968*
3	80	302	4	32	841*	4	86	2896	5	39	1425	5	93	1783*
3	81	1189*	4	33	1461*	4	87	2095	5	40	3695	5	94	2874*
3	82	539	4	34	2150	4	88	773	5	41	218	5	95	4852*
3	83	2652	4	35	3298	4	89	2998*	5	42	1659	5	96	87*
3	84	1226*	4	36	1273	4	90	877	5	43	1105	5	97	1922*
3	85	431	4	37	839*	4	91	2518*	5	44	2386	5	98	1674*
3	86	2026	4	38	997	4	92	1245	5	45	2752	5	99	1656
3	87	315*	4	39	1515	4	93	1270*	5	46	2190	5	100	2198
3	88	142	4	40	3286	4	94	1484*	5	47	253	5	101	2738
3	89	3828*	4	41	721	4	95	3433*	5	48	1486	5	102	4540
3	90	1357	4	42	1820	4	96	1219*	5	49	3568	5	103	1544
3	91	2009*	4	43	193*	4	97	438*	5	50	97	5	104	1358*
3	92	727*	4	44	3835	4	98	574	5	51	1510			
3	93	707*	4	45	360*	4	99	1817	5	52	1771	6	6	10000
3	94	2940*	4	46	12	4	100	571	5	53	2998	6	7	6807
3	95	3142*	4	47	1787	4	101	2349	5	54	1914	6	8	5643
3	96	1888*	4	48	3730	4	102	5127	5	55	1514	6	9	2743
3	97	2001*	4	49	2931	4	103	1316	5	56	161*	6	10	3112
3	98	670*	4	50	936*	4	104	388*	5	57	2649	6	11	6576
3	99	2723	4	51	465				5	58	3778	6	12	4421
3	100	1771	4	52	112*	5	5	10000	5	59	3305	6	13	5031
3	101	479*	4	53	1768	5	6	4470	5	60	285*	6	14	6045
3	102	1973	4	54	962	5	7	4326	5	61	227	6	15	6031

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
6	16	1880	6	70	2130	7	25	1681*	7	79	3718*	8	35	1086
6	17	2487	6	71	4656*	7	26	197*	7	80	1159*	8	36	349*
6	18	283	6	72	3658	7	27	41*	7	81	896*	8	37	1789*
6	19	468*	6	73	4307	7	28	105	7	82	2420*	8	38	454*
6	20	1767	6	74	214*	7	29	2203	7	83	5332	8	39	160*
6	21	1757	6	75	1670*	7	30	1335*	7	84	2668*	8	40	4876
6	22	410	6	76	1936	7	31	3553*	7	85	534	8	41	22*
6	23	1724	6	77	1693	7	32	594	7	86	2139	8	42	2852
6	24	4432	6	78	2518*	7	33	516*	7	87	1481	8	43	1900
6	25	531*	6	79	2364*	7	34	1232	7	88	194*	8	44	1477
6	26	304*	6	80	1191*	7	35	1772	7	89	5291*	8	45	392
6	27	150*	6	81	1603*	7	36	948	7	90	3169	8	46	643*
6	28	1147*	6	82	2356*	7	37	850*	7	91	3079*	8	47	866
6	29	661*	6	83	4347	7	38	1753	7	92	2037*	8	48	1483
6	30	2420*	6	84	748*	7	39	2764	7	93	1263*	8	49	4587
6	31	5330*	6	85	1487*	7	40	3353	7	94	499*	8	50	900*
6	32	883*	6	86	53*	7	41	60	7	95	1928*	8	51	1686
6	33	1037*	6	87	66*	7	42	433*	7	96	1282*	8	52	1858
6	34	348	6	88	1104*	7	43	182	7	97	2841*	8	53	2376
6	35	3010	6	89	4302*	7	44	2230	7	98	2341*	8	54	2055
6	36	823	6	90	1519	7	45	1091*	7	99	1575	8	55	324
6	37	513*	6	91	2696*	7	46	729*	7	100	1014	8	56	705*
6	38	670	6	92	466*	7	47	4253	7	101	2237	8	57	1969
6	39	279	6	93	1109	7	48	2665	7	102	4594	8	58	3199
6	40	1952	6	94	1113*	7	49	2208	7	103	125	8	59	3209
6	41	431	6	95	2163*	7	50	348	7	104	695	8	60	1766
6	42	99*	6	96	2828*	7	51	1145				8	61	154*
6	43	91	6	97	3404*	7	52	1034	8	8	10000	8	62	3486
6	44	2119	6	98	1633*	7	53	1644	8	9	5328	8	63	992*
6	45	1323*	6	99	2950	7	54	1343	8	10	3054	8	64	999
6	46	155	6	100	144	7	55	1057	8	11	6019	8	65	4911
6	47	2134	6	101	749	7	56	1733*	8	12	7251	8	66	250*
6	48	2205	6	102	2829	7	57	2666	8	13	3551	8	67	1840
6	49	3186	6	103	478	7	58	2718	8	14	4518	8	68	1637*
6	50	575*	6	104	2656	7	59	2573	8	15	5637	8	69	2785*
6	51	623				7	60	2222	8	16	4871	8	70	1201
6	52	1299	7	7	10000	7	61	379	8	17	4260	8	71	3178*
6	53	2301	7	8	5452	7	62	2647	8	18	3560	8	72	1017
6	54	1645	7	9	4970	7	63	399	8	19	1586	8	73	4986
6	55	208*	7	10	4166	7	64	130*	8	20	4422	8	74	2564
6	56	467*	7	11	5744	7	65	4350	8	21	2085	8	75	134*
6	57	38	7	12	5662	7	66	1119	8	22	835	8	76	3404
6	58	2516	7	13	4518	7	67	341*	8	23	3256	8	77	3460
6	59	4175	7	14	4864	7	68	1021*	8	24	3444	8	78	1274
6	60	1541	7	15	5731	7	69	1619*	8	25	1953	8	79	1705*
6	61	2291	7	16	2902	7	70	2728	8	26	1291	8	80	788
6	62	3594	7	17	3614	7	71	2031*	8	27	377*	8	81	1172*
6	63	111	7	18	878	7	72	1166	8	28	1144	8	82	3361*
6	64	468*	7	19	381	7	73	5272	8	29	1727	8	83	5094
6	65	2277	7	20	3041	7	74	2855	8	30	3383*	8	84	5286*
6	66	1780	7	21	3835	7	75	403	8	31	2514*	8	85	1361
6	67	550	7	22	2368	7	76	4009	8	32	2067*	8	86	344
6	68	1232*	7	23	1692	7	77	552	8	33	2291*	8	87	88*
6	69	609*	7	24	3510	7	78	894	8	34	945	8	88	2496

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
8	89	3314*	9	46	1306	9	100	1676	10	58	3230	11	17	2554
8	90	146	9	47	1965	9	101	3051	10	59	4474	11	18	996
8	91	901*	9	48	1516	9	102	5535	10	60	318*	11	19	241
8	92	633	9	49	779	9	103	460	10	61	2818	11	20	1913
8	93	3949*	9	50	473*	9	104	2570*	10	62	3823	11	21	2236
8	94	727*	9	51	1022				10	63	333	11	22	62
8	95	1283*	9	52	1367	10	10	10000	10	64	1314*	11	23	3188
8	96	806*	9	53	1198	10	11	5060	10	65	2653	11	24	1923
8	97	2151*	9	54	353	10	12	4309	10	66	2*	11	25	639
8	98	1568*	9	55	256*	10	13	2061	10	67	137*	11	26	212
8	99	3715	9	56	8	10	14	1821	10	68	3015*	11	27	1343*
8	100	925*	9	57	4297	10	15	3503	10	69	262*	11	28	1460*
8	101	3711	9	58	3336	10	16	809	10	70	43*	11	29	2055
8	102	5498	9	59	2132	10	17	2557	10	71	2733*	11	30	1445*
8	103	2	9	60	1176	10	18	1492*	10	72	2458	11	31	2335*
8	104	1519*	9	61	363*	10	19	733	10	73	4650	11	32	1106*
			9	62	2107	10	20	3596	10	74	2042	11	33	1708*
9	9	10000	9	63	100*	10	21	1306	10	75	197*	11	34	3621
9	10	4734	9	64	387*	10	22	4163	10	76	2080	11	35	1391
9	11	4198	9	65	538	10	23	2107	10	77	2076*	11	36	2498
9	12	5773	9	66	1465*	10	24	86*	10	78	552	11	37	663
9	13	1185	9	67	2434	10	25	797*	10	79	1076*	11	38	2348
9	14	2020	9	68	2173*	10	26	146*	10	80	2055	11	39	2767
9	15	3428	9	69	2185*	10	27	2392*	10	81	1502	11	40	3989
9	16	4618	9	70	312*	10	28	108*	10	82	1031*	11	41	1940
9	17	4547	9	71	277	10	29	1420*	10	83	4912	11	42	2685
9	18	3092	9	72	1971*	10	30	3105*	10	84	487*	11	43	1497
9	19	1910	9	73	3745	10	31	285	10	85	18	11	44	4691
9	20	5043	9	74	4216	10	32	1725*	10	86	3045	11	45	377
9	21	1416	9	75	1640	10	33	1327*	10	87	1555	11	46	230
9	22	4091	9	76	57	10	34	543	10	88	1731	11	47	2350
9	23	3788	9	77	3194	10	35	1842	10	89	617	11	48	4905
9	24	3045	9	78	1330	10	36	2552	10	90	1527	11	49	3020
9	25	1285	9	79	830*	10	37	2455*	10	91	849*	11	50	1128*
9	26	478*	9	80	1782	10	38	11*	10	92	201*	11	51	374
9	27	424*	9	81	2136	10	39	1524	10	93	1911*	11	52	147*
9	28	4155	9	82	2200*	10	40	57*	10	94	3951*	11	53	2129
9	29	2364	9	83	3649	10	41	2482*	10	95	5015*	11	54	1139
9	30	3957*	9	84	164	10	42	162	10	96	3353*	11	55	259
9	31	960*	9	85	2028	10	43	1639*	10	97	2202*	11	56	299*
9	32	3380*	9	86	4448	10	44	196*	10	98	743	11	57	3168
9	33	1150*	9	87	1252*	10	45	554*	10	99	355*	11	58	4667
9	34	1344	9	88	2799	10	46	1075	10	100	1097	11	59	5227
9	35	2392	9	89	2126*	10	47	2952	10	101	1769	11	60	2258
9	36	191*	9	90	681	10	48	754	10	102	4415	11	61	2206
9	37	146*	9	91	951	10	49	2679	10	103	1016	11	62	5531
9	38	641*	9	92	954*	10	50	1361*	10	104	545*	11	63	1029
9	39	1782	9	93	2826*	10	51	814*				11	64	2118
9	40	2182	9	94	143	10	52	409	11	11	10000	11	65	4321
9	41	143*	9	95	1288*	10	53	638	11	12	6236	11	66	968
9	42	596*	9	96	1585	10	54	957*	11	13	4596	11	67	658
9	43	561*	9	97	631*	10	55	2773	11	14	5453	11	68	2486*
9	44	2975	9	98	2617*	10	56	2188*	11	15	5549	11	69	1536*
9	45	1270	9	99	1540	10	57	2124	11	16	2312	11	70	158*

Var. (A)	Var. (B)	Corr. Coef. (r)
11	71	3082*
11	72	2957
11	73	6333
11	74	2496
11	75	2686*
11	76	1475
11	77	1374
11	78	1625*
11	79	2729*
11	80	1073*
11	81	142*
11	82	2933*
11	83	6378
11	84	2021*
11	85	2793*
11	86	2638
11	87	1638
11	88	1796
11	89	2353*
11	90	608*
11	91	641*
11	92	3011
11	93	1522*
11	94	383*
11	95	2340*
11	96	709*
11	97	475*
11	98	97
11	99	1122
11	100	820
11	101	2100
11	102	4753
11	103	498
11	104	2156*
12	12	10000
12	13	2592
12	14	3458
12	15	4236
12	16	2830
12	17	2708
12	18	1592
12	19	835
12	20	2789
12	21	2469
12	22	547
12	23	1846
12	24	2561
12	25	659
12	26	1948*
12	27	1369*
12	28	691*
12	29	3917
12	30	1846*

Var. (A)	Var. (B)	Corr. Coef. (r)
12	31	2373*
12	32	146
12	33	1277*
12	34	325
12	35	783
12	36	489
12	37	3844*
12	38	2657*
12	39	0
12	40	2060
12	41	565
12	42	249*
12	43	2246
12	44	2110
12	45	181
12	46	978
12	47	1887
12	48	3296
12	49	3631
12	50	80
12	51	1944
12	52	1127
12	53	1230
12	54	1477
12	55	1655*
12	56	150*
12	57	3174
12	58	3081
12	59	2988
12	60	1998
12	61	337*
12	62	2976
12	63	172*
12	64	1619*
12	65	4868
12	66	1197*
12	67	421
12	68	1290*
12	69	2767*
12	70	637
12	71	593*
12	72	2528
12	73	4247
12	74	3758
12	75	390*
12	76	764
12	77	1661
12	78	3648
12	79	1234*
12	80	758
12	81	774*
12	82	1499*
12	83	4475
12	84	2386*

Var. (A)	Var. (B)	Corr. Coef. (r)
12	85	1339
12	86	974
12	87	0
12	88	1158
12	89	2551*
12	90	687
12	91	347*
12	92	0
12	93	6371*
12	94	962*
12	95	1091*
12	96	558*
12	97	837*
12	98	405*
12	99	2582
12	100	612*
12	101	2008
12	102	4327
12	103	1603*
12	104	4743*
13	13	10000
13	14	5054
13	15	3132
13	16	644
13	17	1282
13	18	753*
13	19	1214*
13	20	2489
13	21	398
13	22	1967*
13	23	2277
13	24	1534
13	25	1276*
13	26	278
13	27	635
13	28	2052*
13	29	1421*
13	30	1505
13	31	1620*
13	32	2125
13	33	1774
13	34	1966
13	35	1549
13	36	2004
13	37	568*
13	38	2987
13	39	53*
13	40	310*
13	41	1444
13	42	1848
13	43	122
13	44	2311
13	45	1158*

Var. (A)	Var. (B)	Corr. Coef. (r)
13	46	264*
13	47	236*
13	48	4664
13	49	927
13	50	935
13	51	461
13	52	545
13	53	100*
13	54	1055*
13	55	2153*
13	56	2649*
13	57	1702*
13	58	1823
13	59	2606
13	60	1716
13	61	3352
13	62	1881
13	63	512
13	64	1202
13	65	286*
13	66	1724
13	67	62*
13	68	387*
13	69	1794
13	70	534
13	71	3476*
13	72	2005
13	73	3041
13	74	2160*
13	75	0
13	76	2987
13	77	65
13	78	1182*
13	79	2860*
13	80	476*
13	81	768*
13	82	1937*
13	83	2751
13	84	3050*
13	85	947*
13	86	1088
13	87	1649*
13	88	334*
13	89	2547*
13	90	718
13	91	1864*
13	92	1840
13	93	59*
13	94	730
13	95	274
13	96	2823*
13	97	1989*
13	98	481
13	99	974

Var. (A)	Var. (B)	Corr. Coef. (r)
13	100	150
13	101	72
13	102	193
13	103	2553
13	104	414*
14	14	10000
14	15	4213
14	16	201*
14	17	1058
14	18	2222*
14	19	885*
14	20	950
14	21	1228
14	22	2117*
14	23	1132
14	24	1423
14	25	3224*
14	26	2311*
14	27	2997*
14	28	84*
14	29	1866*
14	30	679*
14	31	3123*
14	32	1276
14	33	189*
14	34	659*
14	35	1513
14	36	715*
14	37	897*
14	38	1267
14	39	227
14	40	2949
14	41	889*
14	42	660
14	43	2080
14	44	1705
14	45	2983*
14	46	1090*
14	47	2969
14	48	993
14	49	484
14	50	980*
14	51	1126*
14	52	86*
14	53	78
14	54	978*
14	55	1485*
14	56	1866*
14	57	1716
14	58	1798
14	59	3205
14	60	696
14	61	1263

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
14	62	3354	15	25	483	15	79	3003*	16	43	2086	16	97	130*
14	63	405	15	26	824	15	80	2243*	16	44	3967	16	98	1879*
14	64	110	15	27	738*	15	81	2192*	16	45	4244	16	99	926*
14	65	1904	15	28	1444	15	82	47	16	46	1900	16	100	918*
14	66	295*	15	29	1032	15	83	4041	16	47	1455	16	101	5150
14	67	600	15	30	2048*	15	84	3154*	16	48	2264	16	102	4435
14	68	1226*	15	31	1438*	15	85	605	16	49	301*	16	103	2682*
14	69	956*	15	32	833*	15	86	1193	16	50	63	16	104	2254*
14	70	1994	15	33	1657*	15	87	942*	16	51	790*			
14	71	2438*	15	34	688	15	88	665	16	52	1864*	17	17	10000
14	72	2325	15	35	929	15	89	3160*	16	53	1265*	17	18	4254
14	73	3425	15	36	945	15	90	2974	16	54	1416*	17	19	5659
14	74	1700	15	37	1083*	15	91	3182*	16	55	1109*	17	20	8097
14	75	1385	15	38	467	15	92	34*	16	56	1380	17	21	6438
14	76	3991	15	39	1033*	15	93	1810	16	57	1178	17	22	5410
14	77	1016	15	40	4194	15	94	617*	16	58	3270	17	23	3827
14	78	2237*	15	41	165*	15	95	1244*	16	59	1681	17	24	6080
14	79	3059*	15	42	3394	15	96	1633*	16	60	1102	17	25	1365
14	80	1369*	15	43	32	15	97	963*	16	61	165*	17	26	2755
14	81	1084*	15	44	1651	15	98	592	16	62	2615	17	27	1350
14	82	1616*	15	45	804	15	99	1797	16	63	1619	17	28	2723
14	83	3678	15	46	118	15	100	1180	16	64	228*	17	29	561
14	84	2944*	15	47	553	15	101	3825	16	65	4629	17	30	144*
14	85	3546*	15	48	3079	15	102	3507	16	66	1656	17	31	28*
14	86	2707*	15	49	2557	15	103	1807	16	67	901	17	32	423*
14	87	102	15	50	3422*	15	104	2441	16	68	2180*	17	33	1094*
14	88	1633*	15	51	1583*				16	69	1636*	17	34	3782
14	89	5344*	15	52	361	16	16	10000	16	70	350	17	35	670
14	90	216	15	53	1075	16	17	8909	16	71	1796*	17	36	216
14	91	514*	15	54	505	16	18	7856	16	72	412*	17	37	1129
14	92	1885	15	55	65*	16	19	4399	16	73	3618	17	38	33
14	93	1571	15	56	2032*	16	20	7885	16	74	1340	17	39	409
14	94	1357	15	57	1931	16	21	6302	16	75	638*	17	40	2454
14	95	1306	15	58	2302	16	22	4520	16	76	725	17	41	2325
14	96	325*	15	59	3261	16	23	3187	16	77	3414	17	42	1127
14	97	2176*	15	60	1630	16	24	5807	16	78	38*	17	43	2192
14	98	1460*	15	61	83*	16	25	4713	16	79	562*	17	44	3860
14	99	1096	15	62	2678	16	26	3308	16	80	1184*	17	45	3100
14	100	1808*	15	63	1057*	16	27	3314	16	81	1248	17	46	3447
14	101	1070*	15	64	369	16	28	4096	16	82	2577*	17	47	2968
14	102	575	15	65	3070	16	29	3102	16	83	3133	17	48	1688
14	103	253*	15	66	1049*	16	30	361	16	84	1814*	17	49	959*
14	104	644	15	67	1256	16	31	308*	16	85	2085	17	50	1088
			15	68	922*	16	32	415*	16	86	2695	17	51	754*
15	15	10000	15	69	2650*	16	33	1958*	16	87	798	17	52	1904*
15	16	1808	15	70	1098	16	34	4407	16	88	1037	17	53	1633*
15	17	1001	15	71	2514*	16	35	83*	16	89	2450*	17	54	2358*
15	18	2301	15	72	1927	16	36	770	16	90	2132	17	55	175*
15	19	2855*	15	73	3614	16	37	1035	16	91	138*	17	56	1110
15	20	980	15	74	1851	16	38	126*	16	92	3578*	17	57	1450
15	21	992	15	75	630	16	39	408*	16	93	2036*	17	58	2901
15	22	1733	15	76	2029	16	40	3795	16	94	751	17	59	1351
15	23	456	15	77	1660	16	41	3100	16	95	607*	17	60	1046
15	24	2814	15	78	34*	16	42	2308	16	96	2196	17	61	1548

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
17	62	2851	18	28	4860	18	82	1117*	19	49	1217	19	103	1276*
17	63	1273	18	29	5238	18	83	1198	19	50	3943	19	104	2996*
17	64	835*	18	30	602	18	84	1043*	19	51	2173			
17	65	3822	18	31	684*	18	85	695	19	52	1513	20	20	10000
17	66	1996	18	32	500*	18	86	2057	19	53	1017	20	21	4848
17	67	480	18	33	2525*	18	87	156	19	54	1318	20	22	4823
17	68	1853*	18	34	3853	18	88	404	19	55	1058	20	23	2882
17	69	600	18	35	934*	18	89	751*	19	56	1414	20	24	3910
17	70	1174	18	36	1760	18	90	1510	19	57	2822	20	25	3282
17	71	1941*	18	37	683	18	91	60*	19	58	212*	20	26	1915
17	72	354	18	38	51	18	92	2924*	19	59	172*	20	27	2366
17	73	4007	18	39	1213*	18	93	2529*	19	60	668	20	28	2530
17	74	1583	18	40	3911	18	94	1115	19	61	203*	20	29	222
17	75	1134*	18	41	2822	18	95	405	19	62	221	20	30	348
17	76	2314	18	42	2883	18	96	2009	19	63	656	20	31	6
17	77	2293	18	43	637	18	97	800	19	64	3405	20	32	966
17	78	702*	18	44	2551	18	98	48*	19	65	1303	20	33	833
17	79	885*	18	45	4397	18	99	693*	19	66	239	20	34	2694
17	80	1498*	18	46	297*	18	100	1001*	19	67	319	20	35	561
17	81	964	18	47	876*	18	101	4444	19	68	552	20	36	352*
17	82	3023*	18	48	2014	18	102	3202	19	69	102*	20	37	1330*
17	83	3602	18	49	473	18	103	424*	19	70	2029	20	38	1171*
17	84	1479*	18	50	1522*	18	104	1563*	19	71	1355	20	39	793*
17	85	2458	18	51	647*				19	72	2655*	20	40	3162
17	86	2706	18	52	1066*	19	19	10000	19	73	1717	20	41	1269
17	87	980	18	53	334*	19	20	3561	19	74	2065	20	42	2117
17	88	1342	18	54	237	19	21	3590	19	75	669	20	43	2012
17	89	2778*	18	55	1640*	19	22	2351	19	76	46	20	44	1973
17	90	2029	18	56	1338	19	23	315*	19	77	602	20	45	3678
17	91	166*	18	57	130	19	24	3356	19	78	1490	20	46	1089
17	92	3165*	18	58	2556	19	25	11*	19	79	524	20	47	787
17	93	1017*	18	59	1426	19	26	1111*	19	80	108	20	48	1487
17	94	168	18	60	469	19	27	635*	19	81	734	20	49	96
17	95	1382*	18	61	2428*	19	28	1891	19	82	3395*	20	50	553
17	~~96~~	~~1465~~	18	62	1183	19	29	417	19	83	1424	20	51	858*
17	97	871*	18	63	1370	19	30	1141*	19	84	68*	20	52	1676*
17	98	2597*	18	64	599	19	31	1718	19	85	2287	20	53	2229*
17	99	841*	18	65	3907	19	32	3286*	19	86	1179	20	54	2726*
17	100	570*	18	66	1115	19	33	1144*	19	87	1826	20	55	327
17	101	4321	18	67	780	19	34	300	~~19~~	~~88~~	~~2390~~	~~20~~	~~56~~	~~1925~~
17	102	4078	18	68	2020*	19	35	302*	19	89	603	20	57	977
17	103	3636*	18	69	4002*	19	36	1771*	19	90	919*	20	58	2323
17	104	2009*	18	70	804*	19	37	193	19	91	1737	20	59	1983
			18	71	1233*	19	38	417	19	92	1202*	20	60	48*
18	18	10000	18	72	1173*	19	39	707*	19	93	1328*	20	61	519
18	19	1045	18	73	1631	19	40	296	19	94	906	20	62	2244
18	20	4776	18	74	179	19	41	121*	19	95	1304*	20	63	1933
18	21	3971	18	75	393	19	42	1622	19	96	1623	20	64	2114*
18	22	2289	18	76	2045*	19	43	55	19	97	1264*	20	65	3051
18	23	989	18	77	3354	19	44	383*	19	98	2851*	20	66	616
18	24	3062	18	78	608	19	45	242	19	99	1522	20	67	1199
18	25	7454	18	79	99	19	46	1680	19	100	681	20	68	2212*
18	26	3236	18	80	163*	19	47	2773	19	101	3033	20	69	1041*
18	27	5017	18	81	1460	19	48	671*	19	102	3110	20	70	666

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
20	71	1701*	21	40	3234	21	94	2661	22	64	1490*	23	35	3043
20	72	832*	21	41	347*	21	95	972	22	65	2611	23	36	1551
20	73	3481	21	42	1782	21	96	825	22	66	259*	23	37	289
20	74	1420	21	43	1080*	21	97	798	22	67	1381	23	38	312*
20	75	467	21	44	2156	21	98	258	22	68	551*	23	39	2279
20	76	2264	21	45	2593	21	99	1660*	22	69	376	23	40	503*
20	77	2784	21	46	293	21	100	1216*	22	70	1366	23	41	3666
20	78	526*	21	47	2159	21	101	3257	22	71	77*	23	42	2824*
20	79	1055*	21	48	1576	21	102	2545	22	72	360*	23	43	2676
20	80	558	21	49	1791*	21	103	4103*	22	73	2068	23	44	3501
20	81	2092	21	50	1377	21	104	434*	22	74	2684	23	45	617
20	82	3222*	21	51	5*				22	75	614*	23	46	319
20	83	3234	21	52	1637*	22	22	10000	22	76	46	23	47	1405
20	84	1641*	21	53	667*	22	23	399*	22	77	931	23	48	781
20	85	2374	21	54	766*	22	24	2472	22	78	542	23	49	1227
20	86	2391	21	55	170	22	25	8	22	79	1837*	23	50	982*
20	87	386*	21	56	641	22	26	3556	22	80	1255	23	51	232*
20	88	1340	21	57	360	22	27	544*	22	81	686*	23	52	2311*
20	89	2089*	21	58	3315	22	28	2605	22	82	161*	23	53	324*
20	90	3686	21	59	1210	22	29	1263	22	83	2065	23	54	1071*
20	91	530*	21	60	2790	22	30	1031*	22	84	1234	23	55	692*
20	92	4335*	21	61	728	22	31	346	22	85	3396	23	56	699
20	93	2577*	21	62	3696	22	32	1765*	22	86	2469	23	57	30*
20	94	1062*	21	63	2294	22	33	150*	22	87	727*	23	58	4422
20	95	1874*	21	64	979*	22	34	3875	22	88	3147	23	59	2508
20	96	1370	21	65	4496	22	35	1436	22	89	1337*	23	60	1051
20	97	609*	21	66	3592	22	36	1812	22	90	1839	23	61	3139
20	98	1162*	21	67	3139*	22	37	1141	22	91	114*	23	62	3678
20	99	423*	21	68	961*	22	38	1239	22	92	2971*	23	63	115*
20	100	1591*	21	69	197*	22	39	19	22	93	597*	23	64	1532*
20	101	3878	21	70	1189	22	40	963	22	94	2303*	23	65	1642
20	102	3830	21	71	2110*	22	41	1715	22	95	1998*	23	66	1897
20	103	304*	21	72	322	22	42	1420	22	96	1752*	23	67	1211
20	104	2122*	21	73	3908	22	43	382	22	97	1560*	23	68	2849*
			21	74	984	22	44	2002	22	98	435*	23	69	1559
21	21	10000	21	75	28*	22	45	3839	22	99	1873*	23	70	1990*
21	22	2389	21	76	618	22	46	4437	22	100	133	23	71	3350*
21	23	1169*	21	77	1328*	22	47	2026	22	101	4611	23	72	2249
21	24	3600	21	78	1790	22	48	946	22	102	3634	23	73	3502
21	25	1712	21	79	610*	22	49	332*	22	103	1353*	23	74	79
21	26	1157	21	80	2258*	22	50	1525*	22	104	347*	23	75	1578*
21	27	1089	21	81	2671	22	51	2582*				23	76	2347
21	28	786	21	82	2971*	22	52	238*	23	23	10000	23	77	2773
21	29	2028	21	83	3422	22	53	1581*	23	24	1358	23	78	4093*
21	30	685	21	84	589*	22	54	2446*	23	25	1871	23	79	392*
21	31	692	21	85	783*	22	55	1793	23	26	1429	23	80	461*
21	32	1077	21	86	1246	22	56	145	23	27	1411	23	81	2119
21	33	2898*	21	87	2013	22	57	2868	23	28	905	23	82	2186*
21	34	2159	21	88	2374*	22	58	81	23	29	1881*	23	83	3348
21	35	3832*	21	89	2040*	22	59	776	23	30	226	23	84	1538*
21	36	121	21	90	2860	22	60	559*	23	31	875*	23	85	84
21	37	96	21	91	299*	22	61	874	23	32	273	23	86	3141
21	38	487	21	92	3426*	22	62	130*	23	33	56	23	87	1255
21	39	1386	21	93	43*	22	63	96*	23	34	2897	23	88	1066

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
23	89	1715*	24	61	345*	25	34	1951	25	88	400*	26	62	1363*
23	90	692*	24	62	271*	25	35	958*	25	89	625	26	63	318
23	91	1030*	24	63	369	25	36	140	25	90	983	26	64	546*
23	92	1538	24	64	1393*	25	37	1628*	25	91	365*	26	65	194*
23	93	1588*	24	65	1864	25	38	2190*	25	92	1899*	26	66	689
23	94	1599*	24	66	66*	25	39	1258*	25	93	1973*	26	67	1453
23	95	2306*	24	67	1995	25	40	2227	25	94	736	26	68	2115*
23	96	1698	24	68	1640*	25	41	2232	25	95	305	26	69	206
23	97	876*	24	69	714*	25	42	2151	25	96	2099	26	70	491*
23	98	3232*	24	70	1427	25	43	159*	25	97	1271	26	71	2589*
23	99	663*	24	71	682*	25	44	736	25	98	800	26	72	697
23	100	1303	24	72	117	25	45	4225	25	99	1355*	26	73	952*
23	101	313*	24	73	1011	25	46	3498*	25	100	597*	26	74	2171*
23	102	2690	24	74	497	25	47	3094*	25	101	3274	26	75	1978*
23	103	1850*	24	75	2361*	25	48	631	25	102	3030	26	76	2454
23	104	1589*	24	76	1589	25	49	2159	25	103	905	26	77	267
			24	77	3045	25	50	1349*	25	104	697*	26	78	2468*
24	24	10000	24	78	1314*	25	51	850*				26	79	698
24	25	193*	24	79	712*	25	52	2058*	26	26	10000	26	80	1922
24	26	2338	24	80	618*	25	53	394*	26	27	625	26	81	424*
24	27	1633	24	81	1634*	25	54	694	26	28	381*	26	82	621
24	28	1279	24	82	199	25	55	1292*	26	29	430	26	83	1051*
24	29	111	24	83	771	25	56	2732	26	30	1257*	26	84	896*
24	30	1010*	24	84	1752*	25	57	626*	26	31	2056*	26	85	461
24	31	2164*	24	85	3589	25	58	3318	26	32	83	26	86	164
24	32	161	24	86	1196	25	59	2633	26	33	1838*	26	87	1888*
24	33	631*	24	87	1184*	25	60	1925	26	34	4464	26	88	2185
24	34	963	24	88	212*	25	61	34	26	35	594*	26	89	1183
24	35	745	24	89	3697*	25	62	3179	26	36	3787	26	90	1063
24	36	1275*	24	90	3930	25	63	1363	26	37	2809	26	91	202
24	37	2304	24	91	3008*	25	64	731*	26	38	3764	26	92	393*
24	38	269	24	92	3841*	25	65	2600	26	39	162*	26	93	671*
24	39	1771*	24	93	895	25	66	1243	26	40	1315	26	94	339
24	40	2594	24	94	200	25	67	1463	26	41	2602	26	95	1280
24	41	942	24	95	825*	25	68	1361*	26	42	1863	26	96	2571*
24	42	238	24	96	544*	25	69	2042*	26	43	1349	26	97	1267
24	43	2813	24	97	369*	25	70	2904*	26	44	2059	26	98	2060
24	44	3362	24	98	847*	25	71	2409*	26	45	1646	26	99	2032*
24	45	554	24	99	2038	25	72	625*	26	46	3100	26	100	2121*
24	46	3573	24	100	723	25	73	2523	26	47	197	26	101	2018
24	47	2293	24	101	3319	25	74	627*	26	48	863	26	102	415*
24	48	1989	24	102	1424	25	75	546*	26	49	185	26	103	178
24	49	1952	24	103	1467*	25	76	2979*	26	50	1910*	26	104	603*
24	50	1913	24	104	433	25	77	2798	26	51	1785*			
24	51	1633				25	78	73	26	52	138*	27	27	10000
24	52	1658	25	25	10000	25	79	85	26	53	1092*	27	28	1371
24	53	1749	25	26	101	25	80	199*	26	54	2691*	27	29	959
24	54	1184	25	27	4420	25	81	3024	26	55	2333	27	30	2359
24	55	2259*	25	28	2075	25	82	2365*	26	56	834*	27	31	1847*
24	56	560	25	29	2998	25	83	2219	26	57	2626*	27	32	1283
24	57	620	25	30	2005	25	84	185	26	58	314	27	33	975
24	58	1296	25	31	966	25	85	211*	26	59	619*	27	34	436
24	59	312	25	32	640*	25	86	1209	26	60	2486*	27	35	955
24	60	349*	25	33	1265*	25	87	1774	26	61	122*	27	36	165*

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
27	37	2319	27	91	3085*	28	67	279	29	44	2532	29	98	835
27	38	308	27	92	2827*	28	68	334*	29	45	2440	29	99	129*
27	39	893*	27	93	1123*	28	69	1192*	29	46	1282*	29	100	797
27	40	1197	27	94	519*	28	70	68	29	47	1141	29	101	2977
27	41	1303	27	95	1277*	28	71	388	29	48	4421	29	102	3121
27	42	804*	27	96	1885	28	72	823*	29	49	976*	29	103	6*
27	43	843*	27	97	481	28	73	46*	29	50	773*	29	104	3501*
27	44	227	27	98	687*	28	74	791	29	51	59*			
27	45	1468	27	99	567	28	75	3545	29	52	1009*	30	30	10000
27	46	235	27	100	2500	28	76	224*	29	53	212	30	31	4029
27	47	3577*	27	101	1250*	28	77	3046	29	54	1768	30	32	7470
27	48	495*	27	102	919*	28	78	995	29	55	145*	30	33	5310
27	49	1010*	27	103	545	28	79	1817	29	56	147	30	34	3400
27	50	1049	27	104	497*	28	80	886	29	57	2831	30	35	720*
27	51	1966				28	81	1265	29	58	422	30	36	560
27	52	746*	28	28	10000	28	82	179*	29	59	37*	30	37	772*
27	53	648	28	29	351	28	83	364*	29	60	1882	30	38	482*
27	54	2581	28	30	2761*	28	84	405	29	61	2980*	30	39	693
27	55	285*	28	31	515*	28	85	1063*	29	62	102*	30	40	1771
27	56	1089	28	32	3492*	28	86	136	29	63	328	30	41	5145
27	57	3491*	28	33	1577*	28	87	1645*	29	64	2229	30	42	1654
27	58	1355	28	34	286	28	88	937*	29	65	3189	30	43	4617
27	59	1242*	28	35	89*	28	89	196	29	66	2039*	30	44	1500
27	60	3129*	28	36	893	28	90	878*	29	67	897	30	45	1796
27	61	2704*	28	37	1313	28	91	1784	29	68	839	30	46	2615*
27	62	1852*	28	38	318*	28	92	1819*	29	69	3444*	30	47	1496*
27	63	380*	28	39	1787*	28	93	234*	29	70	81	30	48	3547
27	64	2042*	28	40	122	28	94	246*	29	71	2816	30	49	2453*
27	65	125	28	41	945*	28	95	910*	29	72	2333*	30	50	903*
27	66	2943	28	42	300*	28	96	1750	29	73	1519	30	51	3449*
27	67	1981*	28	43	976*	28	97	3169*	29	74	2873	30	52	4614*
27	68	3568*	28	44	727	28	98	3879*	29	75	971*	30	53	3887*
27	69	2223*	28	45	1198	28	99	106*	29	76	2053*	30	54	1555*
27	70	2652*	28	46	2555	28	100	1319*	29	77	818	30	55	1813*
27	71	57	28	47	1852	28	101	1158	29	78	4815	30	56	61
27	72	391	28	48	2168*	28	102	1043	29	79	237	30	57	69*
27	73	2125*	28	49	733*	28	103	1461*	29	80	61	30	58	734
27	74	3260*	28	50	838*	28	104	352*	29	81	1313*	30	59	169*
27	75	755	28	51	522*				29	82	635	30	60	31*
27	76	3092*	28	52	784	29	29	10000	29	83	1450	30	61	946*
27	77	266	28	53	495*	29	30	750	29	84	494*	30	62	517
27	78	1498*	28	54	1736*	29	31	263	29	85	1017	30	63	2847
27	79	802	28	55	2065*	29	32	497*	29	86	2803	30	64	731*
27	80	2547*	28	56	1287	29	33	2554*	29	87	797	30	65	291
27	81	1253	28	57	1632	29	34	3175	29	88	2543	30	66	1163
27	82	448	28	58	383	29	35	287*	29	89	219*	30	67	1260*
27	83	2187*	28	59	24	29	36	1528	29	90	342*	30	68	672*
27	84	467	28	60	68	29	37	1421	29	91	2045	30	69	845*
27	85	1023	28	61	996*	29	38	319	29	92	1154*	30	70	1313*
27	86	2389	28	62	204	29	39	1923	29	93	3929*	30	71	1719
27	87	2575	28	63	295	29	40	3201	29	94	1755	30	72	997*
27	88	1646*	28	64	2092	29	41	2821	29	95	1406	30	73	55
27	89	798*	28	65	1122	29	42	1851	29	96	1908	30	74	5
27	90	1885	28	66	252	29	43	1524	29	97	1995	30	75	980*

Var. (A)	Var. (B)	Corr. Coef. (r)
30	76	481*
30	77	421
30	78	2228*
30	79	4173*
30	80	2575*
30	81	258*
30	82	414*
30	83	175*
30	84	83*
30	85	1097
30	86	798
30	87	2969
30	88	487*
30	89	1760*
30	90	2088
30	91	4066*
30	92	1166*
30	93	446
30	94	212
30	95	979
30	96	1440
30	97	794
30	98	1016
30	99	4185*
30	100	1163
30	101	1234
30	102	1420*
30	103	737*
30	104	1662*
31	31	10000
31	32	1764
31	33	1500
31	34	1237
31	35	3657*
31	36	1044*
31	37	1451*
31	38	2071*
31	39	1732
31	40	2024
31	41	97
31	42	3668
31	43	837
31	44	1578*
31	45	3062
31	46	1632*
31	47	1618*
31	48	1916
31	49	1387*
31	50	146*
31	51	1481*
31	52	1368*
31	53	882*
31	54	470

Var. (A)	Var. (B)	Corr. Coef. (r)
31	55	1103
31	56	957*
31	57	1933
31	58	1453
31	59	278*
31	60	2001
31	61	60*
31	62	1579
31	63	1391
31	64	2549
31	65	1059
31	66	1255*
31	67	738*
31	68	421
31	69	168
31	70	2222*
31	71	2655
31	72	4582*
31	73	783
31	74	2045
31	75	878
31	76	1636*
31	77	1202*
31	78	2004
31	79	915*
31	80	298
31	81	1158
31	82	695*
31	83	492
31	84	175*
31	85	3844
31	86	4458
31	87	416
31	88	3755
31	89	2882
31	90	821
31	91	1303*
31	92	124*
31	93	1373
31	94	310
31	95	250*
31	96	1225
31	97	1174
31	98	1403
31	99	1307*
31	100	4041
31	101	4138
31	102	1377
31	103	21*
31	104	976*
32	32	10000
32	33	4942
32	34	1746

Var. (A)	Var. (B)	Corr. Coef. (r)
32	35	1101*
32	36	1409
32	37	3249*
32	38	443*
32	39	412
32	40	1063
32	41	2810
32	42	565*
32	43	5098
32	44	279*
32	45	433
32	46	2083*
32	47	40*
32	48	2525
32	49	1514*
32	50	843*
32	51	2226*
32	52	2653*
32	53	2825*
32	54	1389*
32	55	1879*
32	56	920*
32	57	579*
32	58	1318
32	59	854
32	60	1595*
32	61	1514*
32	62	113
32	63	3481
32	64	2858*
32	65	1077
32	66	398
32	67	1303*
32	68	2376*
32	69	2319*
32	70	47*
32	71	182
32	72	539
32	73	26
32	74	332
32	75	658*
32	76	1084
32	77	779*
32	78	2666*
32	79	4469*
32	80	186*
32	81	414*
32	82	128
32	83	23*
32	84	2240*
32	85	1468
32	86	95
32	87	566
32	88	936*

Var. (A)	Var. (B)	Corr. Coef. (r)
32	89	3392*
32	90	4233*
32	91	4680*
32	92	2141*
32	93	938*
32	94	1326*
32	95	265
32	96	54
32	97	383
32	98	1485
32	99	2230*
32	100	199*
32	101	449
32	102	1667*
32	103	705*
32	104	653*
33	33	10000
33	34	534*
33	35	2989
33	36	553*
33	37	877*
33	38	2183*
33	39	582
33	40	1362*
33	41	773
33	42	1094*
33	43	3178
33	44	825*
33	45	896*
33	46	468*
33	47	1550*
33	48	1304
33	49	307
33	50	722*
33	51	916*
33	52	1606*
33	53	3229*
33	54	1654*
33	55	542*
33	56	1412
33	57	1067
33	58	2507*
33	59	3702*
33	60	3221*
33	61	2919*
33	62	3161*
33	63	1834
33	64	53*
33	65	2287*
33	66	1118*
33	67	2224
33	68	344*
33	69	454*

Var. (A)	Var. (B)	Corr. Coef. (r)
33	70	38
33	71	3633
33	72	1121*
33	73	2936*
33	74	688
33	75	1404*
33	76	1160
33	77	2611
33	78	2662*
33	79	4483*
33	80	648*
33	81	2799*
33	82	330*
33	83	2999*
33	84	927
33	85	3071
33	86	97*
33	87	729
33	88	1954
33	89	1196*
33	90	1237
33	91	2597*
33	92	1607*
33	93	104*
33	94	2047*
33	95	1200*
33	96	1408
33	97	1258*
33	98	2029*
33	99	1487*
33	100	1474
33	101	15*
33	102	1782*
33	103	1664
33	104	800*
34	34	10000
34	35	1462*
34	36	5165
34	37	2406
34	38	4167
34	39	3668
34	40	4578
34	41	7583
34	42	4194
34	43	3799
34	44	7120
34	45	5759
34	46	2652
34	47	2043
34	48	6441
34	49	987*
34	50	881*
34	51	1464*

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
34	52	1505*	35	35	10000	35	89	2454*	36	73	2364	37	58	2190*
34	53	362*	35	36	1558	35	90	2534*	36	74	2059*	37	59	4071*
34	54	843*	35	37	1314	35	91	685	36	75	2410*	37	60	1041*
34	55	364*	35	38	659	35	92	1128	36	76	1410*	37	61	267*
34	56	1005	35	39	143*	35	93	213	36	77	1515*	37	62	2880*
34	57	2398	35	40	4117*	35	94	1703*	36	78	957*	37	63	1880*
34	58	2697	35	41	663*	35	95	1522*	36	79	1651*	37	64	1848
34	59	3296	35	42	4457*	35	96	858*	36	80	3703	37	65	3256*
34	60	2699	35	43	105*	35	97	753*	36	81	1262	37	66	2102
34	61	2807	35	44	267	35	98	968*	36	82	922*	37	67	907*
34	62	3135	35	45	4463*	35	99	447	36	83	2271	37	68	1004
34	63	1114	35	46	791	35	100	1173	36	84	609*	37	69	2795
34	64	2077	35	47	2137	35	101	796*	36	85	2571*	37	70	349*
34	65	3456	35	48	49*	35	102	38*	36	86	2073	37	71	2242
34	66	2512	35	49	64*	35	103	1787	36	87	1404*	37	72	716*
34	67	719*	35	50	3186*	35	104	1501	36	88	1139	37	73	2922*
34	68	286*	35	51	2139*				36	89	1369	37	74	2353*
34	69	692	35	52	2205*	36	36	10000	36	90	1471*	37	75	3503*
34	70	391	35	53	2156*	36	37	280	36	91	932	37	76	347*
34	71	2076*	35	54	1741*	36	38	4142	36	92	1894	37	77	371
34	72	861	35	55	1303*	36	39	817	36	93	2327*	37	78	1472*
34	73	4435	35	56	1067*	36	40	1849*	36	94	3781*	37	79	2882
34	74	1624	35	57	658*	36	41	2843	36	95	2874*	37	80	2129*
34	75	2613*	35	58	1848*	36	42	812*	36	96	4824*	37	81	986*
34	76	1172*	35	59	1567*	36	43	266	36	97	3849*	37	82	2126
34	77	3299	35	60	3768*	36	44	1637	36	98	48	37	83	3269*
34	78	2854*	35	61	856*	36	45	303*	36	99	3781*	37	84	1995
34	79	2847*	35	62	2667*	36	46	1721	36	100	1415	37	85	2172*
34	80	914	35	63	2587*	36	47	2806	36	101	827	37	86	1212
34	81	536	35	64	1033*	36	48	3644	36	102	1142	37	87	164
34	82	1120*	35	65	2352*	36	49	543*	36	103	2343*	37	88	435*
34	83	3878	35	66	375	36	50	5028*	36	104	1123*	37	89	622
34	84	399*	35	67	2970	36	51	3836*				37	90	3182*
34	85	594*	35	68	1313*	36	52	2316*	37	37	10000	37	91	1907
34	86	4656	35	69	209	36	53	2797*	37	38	3653	37	92	1424
34	87	967*	35	70	1592	36	54	2628*	37	39	1670	37	93	2789
34	88	3379	35	71	512*	36	55	10*	37	40	790	37	94	1263
34	89	321*	35	72	1293	36	56	809*	37	41	1368	37	95	189
34	90	130*	35	73	1095*	36	57	1070*	37	42	371	37	96	767
34	91	1008*	35	74	1518*	36	58	1534	37	43	76	37	97	2068
34	92	1854	35	75	3197*	36	59	3163	37	44	4840	37	98	422
34	93	1251*	35	76	780	36	60	886*	37	45	571	37	99	756*
34	94	859*	35	77	70	36	61	2466	37	46	3838	37	100	1387
34	95	1391*	35	78	2639*	36	62	1476	37	47	29	37	101	2496*
34	96	882*	35	79	2875*	36	63	723*	37	48	1699	37	102	3279*
34	97	305*	35	80	656*	36	64	1312	37	49	4152*	37	103	1569*
34	98	907	35	81	2486*	36	65	813	37	50	304*	37	104	292
34	99	2518*	35	82	136*	36	66	2768	37	51	473			
34	100	257	35	83	851*	36	67	1902*	37	52	1203*	38	38	10000
34	101	3908	35	84	328	36	68	1866*	37	53	657	38	39	829
34	102	3262	35	85	1473	36	69	380	37	54	143*	38	40	1818
34	103	2606*	35	86	10	36	70	847	37	55	179*	38	41	1902
34	104	2830*	35	87	1764	36	71	4302*	37	56	1696	38	42	1959
			35	88	1834	36	72	4810	37	57	1406*	38	43	1472*

Var. (A)	Var. (B)	Corr. Coef. (r)
38	44	2893
38	45	818*
38	46	1494
38	47	1800
38	48	2202
38	49	45
38	50	319
38	51	393
38	52	2135
38	53	2065
38	54	427
38	55	525*
38	56	1735*
38	57	601
38	58	1314
38	59	2369
38	60	485
38	61	2884
38	62	104*
38	63	138*
38	64	3156
38	65	1194
38	66	2818
38	67	1278*
38	68	857*
38	69	1522
38	70	530
38	71	2614*
38	72	284
38	73	2473
38	74	507*
38	75	1295*
38	76	249*
38	77	2929*
38	78	2341*
38	79	3090*
38	80	1286
38	81	56
38	82	1498*
38	83	2302
38	84	2207*
38	85	2772*
38	86	950
38	87	1298*
38	88	391
38	89	2690*
38	90	2808*
38	91	345
38	92	4529
38	93	1244
38	94	822
38	95	711
38	96	3072*
38	97	12

Var. (A)	Var. (B)	Corr. Coef. (r)
38	98	2226
38	99	94
38	100	90
38	101	793
38	102	819
38	103	1234
38	104	829
39	39	10000
39	40	2153
39	41	226
39	42	937*
39	43	80*
39	44	3728
39	45	237*
39	46	700*
39	47	3456
39	48	1424
39	49	725*
39	50	1876
39	51	2081
39	52	3*
39	53	2190
39	54	2369
39	55	2824
39	56	1029*
39	57	2113
39	58	2695
39	59	304*
39	60	2071
39	61	431
39	62	3082
39	63	539
39	64	2440
39	65	2511
39	66	2917
39	67	1792*
39	68	802*
39	69	663
39	70	785*
39	71	84
39	72	1638*
39	73	2737
39	74	2066
39	75	2708*
39	76	315
39	77	805
39	78	1051*
39	79	2595*
39	80	8*
39	81	919
39	82	1584*
39	83	2254
39	84	1030

Var. (A)	Var. (B)	Corr. Coef. (r)
39	85	49
39	86	5135
39	87	3359
39	88	3129
39	89	1098
39	90	1018*
39	91	1933*
39	92	1956
39	93	203
39	94	693
39	95	1598*
39	96	458
39	97	494
39	98	319*
39	99	163*
39	100	2030
39	101	1441
39	102	2754
39	103	1339*
39	104	177
40	40	10000
40	41	2409
40	42	7456
40	43	3313
40	44	3712
40	45	4344
40	46	971*
40	47	2*
40	48	4139
40	49	1707
40	50	1716
40	51	1740
40	52	2106
40	53	3322
40	54	3380
40	55	791
40	56	792*
40	57	3026
40	58	3290
40	59	2697
40	60	2797
40	61	645*
40	62	3130
40	63	1131
40	64	2396
40	65	4795
40	66	731*
40	67	674
40	68	955*
40	69	2828*
40	70	640*
40	71	249*

Var. (A)	Var. (B)	Corr. Coef. (r)
40	72	2746*
40	73	4119
40	74	3330
40	75	1212
40	76	1268
40	77	3556
40	78	218
40	79	2716*
40	80	526*
40	81	999*
40	82	1027*
40	83	3956
40	84	3774*
40	85	1360
40	86	2950
40	87	128*
40	88	2809
40	89	2269*
40	90	3212
40	91	3720*
40	92	375*
40	93	243*
40	94	2002
40	95	934
40	96	492
40	97	529
40	98	1591
40	99	2086
40	100	450
40	101	4996
40	102	3701
40	103	1355
40	104	1384*
41	41	10000
41	42	2623
41	43	5345
41	44	5715
41	45	5174
41	46	1060
41	47	593*
41	48	5560
41	49	722*
41	50	1039*
41	51	2293*
41	52	2787*
41	53	1769*
41	54	1091*
41	55	1125*
41	56	2508
41	57	1813
41	58	1752
41	59	2874
41	60	2437

Var. (A)	Var. (B)	Corr. Coef. (r)
41	61	1873
41	62	1980
41	63	1712
41	64	269
41	65	2144
41	66	378
41	67	93
41	68	345
41	69	5*
41	70	703*
41	71	56*
41	72	733
41	73	2622
41	74	1498
41	75	1268*
41	76	1342*
41	77	3755
41	78	3181*
41	79	1325*
41	80	1027*
41	81	2*
41	82	863*
41	83	2454
41	84	745
41	85	451*
41	86	2333
41	87	1097*
41	88	1313
41	89	1721*
41	90	76
41	91	1104*
41	92	882
41	93	1454*
41	94	758*
41	95	183*
41	96	1484
41	97	33
41	98	1168*
41	99	2442*
41	100	537
41	101	1335
41	102	1745
41	103	1943*
41	104	3860*
42	42	10000
42	43	1751
42	44	1995
42	45	4932
42	46	695*
42	47	2395*
42	48	4295
42	49	1225
42	50	72*

Var. (A)	Var. (B)	Corr. Coef. (r)
42	51	302*
42	52	977
42	53	1335
42	54	1245
42	55	1714
42	56	174
42	57	2968
42	58	347
42	59	2167
42	60	2228
42	61	278*
42	62	1771
42	63	1025
42	64	4150
42	65	2486
42	66	1767*
42	67	481
42	68	1219
42	69	1950*
42	70	251
42	71	757
42	72	2526*
42	73	2429
42	74	2735
42	75	1140
42	76	235
42	77	2437
42	78	373
42	79	1375*
42	80	706*
42	81	1441*
42	82	434*
42	83	2423
42	84	2502*
42	85	303
42	86	1158
42	87	1134*
42	88	3048
42	89	883
42	90	1056
42	91	1059*
42	92	1248
42	93	786
42	94	629
42	95	19
42	96	156
42	97	1140
42	98	2670
42	99	574
42	100	240*
42	101	4744
42	102	2820
42	103	2214
42	104	1330*
43	43	10000
43	44	2881
43	45	2037
43	46	1032
43	47	2291
43	48	3318
43	49	332
43	50	860*
43	51	1771*
43	52	1911*
43	53	1559*
43	54	752*
43	55	695*
43	56	2237
43	57	2400
43	58	560
43	59	880
43	60	-884*
43	61	1191*
43	62	783
43	63	1560
43	64	547*
43	65	1100
43	66	2591*
43	67	2708
43	68	1177*
43	69	1954*
43	70	163
43	71	1268
43	72	317
43	73	1118
43	74	2608
43	75	2340*
43	76	3269
43	77	4725
43	78	2467*
43	79	1913*
43	80	1079
43	81	2989*
43	82	230
43	83	1290
43	84	2827*
43	85	2047
43	86	38*
43	87	319*
43	88	3074
43	89	2193*
43	90	2527
43	91	2768*
43	92	1658*
43	93	2754*
43	94	2129*
43	95	758*
43	96	790
43	97	1182*
43	98	889*
43	99	321*
43	100	792*
43	101	1872
43	102	280
43	103	1750*
43	104	4047*
44	44	10000
44	45	3426
44	46	3562
44	47	2464
44	48	5750
44	49	1663*
44	50	564
44	51	21
44	52	1901*
44	53	6
44	54	1258*
44	55	2755*
44	56	2308
44	57	2523
44	58	1815
44	59	1247
44	60	3757
44	61	2068
44	62	2799
44	63	486*
44	64	321
44	65	1922
44	66	2452
44	67	414*
44	68	1136
44	69	2532
44	70	375
44	71	738*
44	72	1385
44	73	3472
44	74	1647
44	75	4058*
44	76	68*
44	77	-4645
44	78	2453*
44	79	1634*
44	80	1964*
44	81	20
44	82	103
44	83	3021
44	84	253
44	85	1839*
44	86	2863
44	87	824*
44	88	100
44	89	1781*
44	90	1002*
44	91	343*
44	92	2474
44	93	714
44	94	1148
44	95	113*
44	96	909
44	97	2027
44	98	928
44	99	1425*
44	100	977*
44	101	1627
44	102	1779
44	103	3364*
44	104	1722*
45	45	10000
45	46	2061
45	47	2342*
45	48	4414
45	49	1273*
45	50	557
45	51	806
45	52	269*
45	53	1018
45	54	536
45	55	957*
45	56	3598
45	57	2356
45	58	894
45	59	1606
45	60	3901
45	61	1640
45	62	1529
45	63	1462
45	64	299*
45	65	2457
45	66	97*
45	67	394
45	68	2265
45	69	658
45	70	389
45	71	219
45	72	658*
45	73	2266
45	74	2416
45	75	291
45	76	2994*
45	77	3661
45	78	386*
45	79	720
45	80	959*
45	81	382
45	82	707
45	83	1776
45	84	880
45	85	1229
45	86	3604
45	87	2742*
45	88	1921
45	89	25*
45	90	1966
45	91	421
45	92	1487*
45	93	582*
45	94	338*
45	95	632*
45	96	2735
45	97	1914
45	98	869
45	99	2320
45	100	1870*
45	101	1542*
45	102	2320
45	103	1870*
45	104	1542*
46	46	10000
46	47	1999
46	48	901
46	49	2144*
46	50	2152
46	51	1468
46	52	1959
46	53	554
46	54	1624*
46	55	2119*
46	56	727
46	57	418*
46	58	1088*
46	59	1530*
46	60	1417*
46	61	1544
46	62	1971*
46	63	1395*
46	64	235*
46	65	1578*
46	66	-1379
46	67	204*
46	68	36
46	69	2938
46	70	695
46	71	21
46	72	2819
46	73	1710*
46	74	1382*
46	75	1866*

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
46	76	1120*	47	71	2019*	48	67	387	49	64	820	50	62	75
46	77	969	47	72	1471	48	68	1776	49	65	4125	50	63	2362
46	78	959*	47	73	3320	48	69	396	49	66	2718*	50	64	1797
46	79	1571	47	74	1992	48	70	1999	49	67	3983	50	65	232
46	80	59	47	75	1512*	48	71	329	49	68	3061*	50	66	649
46	81	2087*	47	76	3697	48	72	462	49	69	3238*	50	67	147*
46	82	2262	47	77	1037	48	73	3287	49	70	1813*	50	68	1301
46	83	1962*	47	78	996*	48	74	2057	49	71	1421*	50	69	2004
46	84	1741	47	79	1810*	48	75	2847*	49	72	440*	50	70	968*
46	85	1356	47	80	2139	48	76	912*	49	73	3084	50	71	1360
46	86	1537	47	81	984*	48	77	2514	49	74	3582	50	72	2256*
46	87	3094*	47	82	369*	48	78	522*	49	75	580	50	73	184
46	88	1992	47	83	3261	48	79	2680*	49	76	1162	50	74	441
46	89	1180	47	84	640*	48	80	379*	49	77	2733	50	75	867
46	90	1020*	47	85	749*	48	81	1965*	49	78	731*	50	76	150
46	91	929	47	86	986	48	82	459	49	79	2343*	50	77	153
46	92	715	47	87	748	48	83	2945	49	80	3933	50	78	1152
46	93	141*	47	88	1271	48	84	706*	49	81	1214*	50	79	1120
46	94	563*	47	89	719*	48	85	435	49	82	2211*	50	80	1046*
46	95	1017*	47	90	1238	48	86	4655	49	83	3322	50	81	646*
46	96	1872*	47	91	291	48	87	2519*	49	84	1254*	50	82	189*
46	97	283*	47	92	1290*	48	88	2721	49	85	1750	50	83	373*
46	98	501	47	93	173*	48	89	1212*	49	86	5	50	84	173
46	99	1997*	47	94	858*	48	90	1020	49	87	97*	50	85	1699
46	100	2854*	47	95	1831*	48	91	605*	49	88	2483	50	86	845
46	101	2241*	47	96	2260*	48	92	832	49	89	1007*	50	87	478
46	102	1997*	47	97	2921*	48	93	724*	49	90	1441	50	88	181*
46	103	2854*	47	98	973*	48	94	744*	49	91	3066*	50	89	275
46	104	2241*	47	99	2057	48	95	1174*	49	92	347*	50	90	545
			47	100	2811*	48	96	561*	49	93	3309*	50	91	1125*
47	47	10000	47	101	326	48	97	838	49	94	1962*	50	92	339*
47	48	1137	47	102	2057	48	98	2039	49	95	1754*	50	93	263*
47	49	102	47	103	2811*	48	99	2311	49	96	2119*	50	94	3358
47	50	482	47	104	326	48	100	614*	49	97	2988*	50	95	1193
47	51	92*				48	101	2292*	49	98	1236*	50	96	1608
47	52	131	48	48	10000	48	102	2311	49	99	3335	50	97	1376
47	53	423	48	49	477*	48	103	614*	49	100	703	50	98	35
47	54	630*	48	50	1810*	48	104	2292*	49	101	3211	50	99	4443
47	55	655	48	51	571*				49	102	5233	50	100	1996*
47	56	438	48	52	1687*	49	49	10000	49	103	3664	50	101	6*
47	57	2840	48	53	212*	49	50	965	49	104	1137*	50	102	171*
47	58	187	48	54	269	49	51	3621				50	103	1492
47	59	917	48	55	1845*	49	52	5814	50	50	10000	50	104	1213*
47	60	870	48	56	1379	49	53	4973	50	51	7212			
47	61	1472	48	57	2880	49	54	4665	50	52	5654	51	51	10000
47	62	1523	48	58	640	49	55	1803	50	53	5108	51	52	7626
47	63	777*	48	59	1624	49	56	42	50	54	3487	51	53	8342
47	64	543	48	60	3289	49	57	3517	50	55	1237*	51	54	7250
47	65	1058	48	61	1422	49	58	3480	50	56	299*	51	55	669*
47	66	880	48	62	1120	49	59	3733	50	57	590	51	56	983
47	67	472	48	63	369	49	60	56	50	58	653	51	57	1489
47	68	404	48	64	1740	49	61	289*	50	59	481*	51	58	25
47	69	1043	48	65	1537	49	62	2059	50	60	2485	51	59	1298*
47	70	4326	48	66	301*	49	63	1814	50	61	1428	51	60	1645

Var. (A)	Var. (B)	Corr. Coef. (r)
51	61	565*
51	62	1502*
51	63	256
51	64	1886
51	65	963
51	66	544
51	67	266*
51	68	1128
51	69	301
51	70	506
51	71	1529
51	72	1360*
51	73	395*
51	74	1509
51	75	300
51	76	930*
51	77	1416
51	78	975
51	79	1531
51	80	735
51	81	1849*
51	82	891
51	83	882*
51	84	429*
51	85	1407
51	86	1625
51	87	614*
51	88	752
51	89	6
51	90	933*
51	91	851*
51	92	719
51	93	2407*
51	94	322
51	95	1448*
51	96	948
51	97	520
51	98	222*
51	99	6966
51	100	146*
51	101	1177*
51	102	966
51	103	937
51	104	573*
52	52	10000
52	53	8327
52	54	6214
52	55	287*
52	56	1906*
52	57	2296
52	58	806
52	59	1232
52	60	402

Var. (A)	Var. (B)	Corr. Coef. (r)
52	61	199*
52	62	1202*
52	63	1610
52	64	2839
52	65	2001
52	66	1620*
52	67	1598
52	68	467*
52	69	1177*
52	70	340*
52	71	566
52	72	1947*
52	73	1
52	74	2168
52	75	2160
52	76	554*
52	77	494
52	78	865
52	79	129
52	80	3695
52	81	2825*
52	82	890
52	83	310*
52	84	584*
52	85	1756
52	86	261
52	87	2723*
52	88	1933
52	89	482*
52	90	515*
52	91	1370*
52	92	789
52	93	1700*
52	94	13*
52	95	398*
52	96	2252*
52	97	1953*
52	98	117
52	99	6697
52	100	797*
52	101	882
52	102	1644
52	103	3270
52	104	146
53	53	10000
53	54	8442
53	55	48
53	56	758*
53	57	2384
53	58	2096
53	59	1975
53	60	1926
53	61	304

Var. (A)	Var. (B)	Corr. Coef. (r)
53	62	567
53	63	828
53	64	2643
53	65	2743
53	66	204
53	67	83
53	68	440*
53	69	1162*
53	70	302*
53	71	67*
53	72	1516*
53	73	1561
53	74	2287
53	75	164
53	76	1346*
53	77	554
53	78	436*
53	79	501
53	80	1565
53	81	1959*
53	82	879
53	83	1189
53	84	761*
53	85	570
53	86	2265
53	87	369*
53	88	1404
53	89	890*
53	90	842*
53	91	2318*
53	92	1676
53	93	770*
53	94	420*
53	95	2077*
53	96	918*
53	97	187*
53	98	983
53	99	7149
53	100	869
53	101	341
53	102	2493
53	103	2027
53	104	1207
54	54	10000
54	55	1622
54	56	112
54	57	2093
54	58	1517
54	59	918
54	60	923
54	61	2136*
54	62	197*
54	63	1031*

Var. (A)	Var. (B)	Corr. Coef. (r)
54	64	2109
54	65	3097
54	66	29
54	67	1099*
54	68	724*
54	69	3131*
54	70	57*
54	71	1141
54	72	2197*
54	73	880
54	74	2268
54	75	466
54	76	3249*
54	77	860
54	78	522
54	79	311*
54	80	1284
54	81	1299*
54	82	86
54	83	845
54	84	768*
54	85	2312
54	86	3260
54	87	969
54	88	2209
54	89	507*
54	90	206
54	91	3710*
54	92	532
54	93	1493*
54	94	1327*
54	95	2728*
54	96	364*
54	97	768*
54	98	28
54	99	6592
54	100	4141
54	101	736
54	102	2891
54	103	1193
54	104	631
55	55	10000
55	56	1051
55	57	507
55	58	215
55	59	568*
55	60	2348*
55	61	2005*
55	62	558
55	63	777*
55	64	177
55	65	578
55	66	1772*

Var. (A)	Var. (B)	Corr. Coef. (r)
55	67	676*
55	68	1989*
55	69	1906*
55	70	1039*
55	71	856
55	72	1861*
55	73	21
55	74	1395
55	75	2045
55	76	2269
55	77	718*
55	78	13*
55	79	1796
55	80	1636
55	81	1128
55	82	1329*
55	83	797
55	84	1886
55	85	370
55	86	1853
55	87	2045
55	88	3068
55	89	3908
55	90	2551
55	91	1435*
55	92	2491*
55	93	304*
55	94	2236*
55	95	2601*
55	96	867*
55	97	1850*
55	98	1740*
55	99	500*
55	100	3098
55	101	274
55	102	2465
55	103	1591
55	104	457*
56	56	10000
56	57	766
56	58	1593*
56	59	1304*
56	60	2196
56	61	648
56	62	181
56	63	888*
56	64	1672*
56	65	1681*
56	66	1069
56	67	642*
56	68	3018
56	69	1825
56	70	1272

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
56	71	532	57	76	293	58	82	4717*	59	89	2629*	60	97	257
56	72	213*	57	77	3850	58	83	6485	59	90	818	60	98	486
56	73	240	57	78	649	58	84	1091*	59	91	2100*	60	99	1394
56	74	333	57	79	3802*	58	85	639*	59	92	1554	60	100	1125*
56	75	1919*	57	80	102	58	86	4047	59	93	1318*	60	101	2579
56	76	967*	57	81	2956*	58	87	1912	59	94	2357*	60	102	3300
56	77	4329	57	82	268	58	88	530	59	95	2432*	60	103	2217*
56	78	1523*	57	83	4196	58	89	2581*	59	96	2546*	60	104	1322
56	79	2647	57	84	1096*	58	90	1054	59	97	3029*			
56	80	1143	57	85	1494	58	91	3526*	59	98	106	61	61	10000
56	81	1990	57	86	1933	58	92	349	59	99	264	61	62	5579
56	82	2500*	57	87	645	58	93	1844*	59	100	26*	61	63	581*
56	83	273	57	88	3633	58	94	578	59	101	2774	61	64	510*
56	84	3266	57	89	3045*	58	95	319*	59	102	5549	61	65	18
56	85	2067*	57	90	45*	58	96	422*	59	103	541	61	66	3438
56	86	12	57	91	410	58	97	1350*	59	104	629*	61	67	1077*
56	87	2954*	57	92	411	58	98	742*				61	68	2241
56	88	955*	57	93	1567*	58	99	107	60	60	10000	61	69	7539
56	89	1303	57	94	1387*	58	100	1677	60	61	6058	61	70	371*
56	90	455	57	95	1821*	58	101	3701	60	62	5489	61	71	6431*
56	91	1049	57	96	3611	58	102	5446	60	63	17*	61	72	4348
56	92	2321*	57	97	946*	58	103	22*	60	64	1976	61	73	5851
56	93	984*	57	98	3060*	58	104	2246*	60	65	2367	61	74	1700*
56	94	2032*	57	99	296				60	66	2535	61	75	2658*
56	95	2036*	57	100	1115	59	59	10000	60	67	1816*	61	76	474
56	96	1792	57	101	3895	59	60	3195	60	68	5525	61	77	1261*
56	97	86	57	102	6715	59	61	5135	60	69	4507	61	78	692*
56	98	1016*	57	103	186*	59	62	7671	60	70	1123	61	79	113*
56	99	1121	57	104	2716*	59	63	3029	60	71	2736*	61	80	857
56	100	905*				59	64	271	60	72	345*	61	81	1882
56	101	1057*	58	58	10000	59	65	6032	60	73	6303	61	82	2279*
56	102	189*	58	59	6993	59	66	693	60	74	1710	61	83	5516
56	103	2441*	58	60	2376	59	67	676*	60	75	1043*	61	84	765*
56	104	1101*	58	61	3042	59	68	3571*	60	76	105*	61	85	3020*
			58	62	7997	59	69	1756*	60	77	1306	61	86	423
57	57	10000	58	63	4444	59	70	2195*	60	78	2843	61	87	2344*
57	58	1495	58	64	134*	59	71	5427*	60	79	434*	61	88	1998*
57	59	2344	58	65	7122	59	72	2642	60	80	937*	61	89	742*
57	60	2029	58	66	1880	59	73	7756	60	81	1629	61	90	1722*
57	61	941*	58	67	650*	59	74	2223	60	82	3379*	61	91	952
57	62	1887	58	68	6756*	59	75	535	60	83	5714	61	92	3097
57	63	2583	58	69	1996*	59	76	1018*	60	84	1072*	61	93	1898
57	64	3050	58	70	6398*	59	77	658*	60	85	1443*	61	94	639*
57	65	6045	58	71	3972*	59	78	1438*	60	86	1592	61	95	556*
57	66	4851*	58	72	501	59	79	2336*	60	87	2266*	61	96	3588*
57	67	3446	58	73	6673	59	80	2428	60	88	1452*	61	97	2060*
57	68	8*	58	74	2041	59	81	2721	60	89	1302*	61	98	725
57	69	2848*	58	75	127	59	82	3504*	60	90	1167*	61	99	915*
57	70	740	58	76	395*	59	83	7834	60	91	439	61	100	1304*
57	71	4065	58	77	1100*	59	84	2171*	60	92	2082	61	101	27
57	72	2021*	58	78	1212*	59	85	2500*	60	93	949	61	102	1461
57	73	4019	58	79	2235*	59	86	1727	60	94	2110	61	103	2282*
57	74	9557	58	80	799	59	87	512*	60	95	932	61	104	2014
57	75	1031	58	81	3287	59	88	352*	60	96	22			

Var. (A)	Var. (B)	Corr. Coef. (r)
62	62	10000
62	63	3023
62	64	719
62	65	5866
62	66	2595
62	67	1630*
62	68	2670*
62	69	462
62	70	3472*
62	71	5288*
62	72	2069
62	73	8375
62	74	2040
62	75	811*
62	76	788
62	77	296
62	78	532*
62	79	1760*
62	80	73
62	81	3486
62	82	5344*
62	83	8210
62	84	1186*
62	85	2976*
62	86	2122
62	87	1650
62	88	656*
62	89	1292*
62	90	217
62	91	2049*
62	92	1341
62	93	359*
62	94	86*
62	95	1245*
62	96	851*
62	97	2296*
62	98	927*
62	99	890*
62	100	317*
62	101	3335
62	102	5524
62	103	1825*
62	104	670*
63	63	10000
63	64	1986
63	65	3565
63	66	1428*
63	67	1788
63	68	3990*
63	69	3024*
63	70	4448*
63	71	1770
63	72	2422*

Var. (A)	Var. (B)	Corr. Coef. (r)
63	73	1402
63	74	2937
63	75	916
63	76	1372
63	77	706*
63	78	1900*
63	79	1048*
63	80	260*
63	81	583*
63	82	1616*
63	83	769
63	84	1782
63	85	1265*
63	86	*1
63	87	1521
63	88	593*
63	89	1921*
63	90	957
63	91	954*
63	92	2447*
63	93	1178*
63	94	1191
63	95	863
63	96	2668
63	97	23*
63	98	1291*
63	99	1176*
63	100	2526*
63	101	1565
63	102	1583
63	103	2779
63	104	2492*
64	64	10000
64	65	983
64	66	172*
64	67	647
64	68	1495
64	69	798*
64	70	12
64	71	1727
64	72	2868*
64	73	1153
64	74	1500
64	75	373*
64	76	163*
64	77	698
64	78	1192
64	79	1233*
64	80	11*
64	81	2387*
64	82	1939*
64	83	586
64	84	1705*

Var. (A)	Var. (B)	Corr. Coef. (r)
64	85	611*
64	86	1660
64	87	493
64	88	3916
64	89	1779
64	90	4670*
64	91	1740
64	92	4010
64	93	432
64	94	1220
64	95	851*
64	96	832
64	97	1653*
64	98	1863*
64	99	1749
64	100	1132
64	101	2787
64	102	2150
64	103	2322
64	104	956*
65	65	10000
65	66	508*
65	67	35
65	68	4548*
65	69	4707*
65	70	2096*
65	71	1053*
65	72	400*
65	73	6820
65	74	6808
65	75	1281
65	76	980*
65	77	1190
65	78	879
65	79	4225*
65	80	569
65	81	715
65	82	3184*
65	83	6796
65	84	2795*
65	85	1307
65	86	3022
65	87	2105
65	88	1918
65	89	4536*
65	90	1094
65	91	2349*
65	92	158*
65	93	3424*
65	94	656*
65	95	1160*
65	96	1325
65	97	1705*

Var. (A)	Var. (B)	Corr. Coef. (r)
65	98	2241
65	99	255
65	100	1232
65	101	5499
65	102	8262
65	103	1640*
65	104	2578*
66	66	10000
66	67	6799*
66	68	367
66	69	3409
66	70	1147
66	71	5499*
66	72	2226
66	73	2186
66	74	5384*
66	75	3460*
66	76	1601*
66	77	2307*
66	78	2105*
66	79	1159*
66	80	791*
66	81	4310
66	82	4611*
66	83	1377
66	84	509
66	85	2795*
66	86	1461
66	87	1406
66	88	3015*
66	89	256*
66	90	2466*
66	91	2136*
66	92	2441
66	93	973
66	94	11*
66	95	1780*
66	96	3354*
66	97	441*
66	98	1997
66	99	377
66	100	733*
66	101	466*
66	102	1503*
66	103	3577*
66	104	2714
67	67	10000
67	68	804*
67	69	761*
67	70	1008*
67	71	1427
67	72	1063*

Var. (A)	Var. (B)	Corr. Coef. (r)
67	73	550*
67	74	3070
67	75	336*
67	76	2548
67	77	4143
67	78	1202*
67	79	1637*
67	80	283
67	81	4992*
67	82	2199
67	83	354*
67	84	832*
67	85	3083
67	86	1432*
67	87	425*
67	88	4211
67	89	1474*
67	90	1363
67	91	2135
67	92	1719*
67	93	101
67	94	1928
67	95	2974
67	96	2646
67	97	457
67	98	1824*
67	99	212*
67	100	1062*
67	101	2622
67	102	1968
67	103	4112
67	104	927*
68	68	10000
68	69	5419
68	70	6173
68	71	1124
68	72	463*
68	73	1039*
68	74	739*
68	75	913*
68	76	101
68	77	1800
68	78	3145
68	79	1753
68	80	1335*
68	81	1481*
68	82	1557
68	83	1316*
68	84	206
68	85	541*
68	86	2249*
68	87	3435*
68	88	1471*

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
68	89	1512	70	70	10000	71	89	1085	73	76	1191	74	98	3020*
68	90	1872*	70	71	824*	71	90	429*	73	77	714	74	99	270
68	91	3466	70	72	1529	71	91	1325	73	78	308	74	100	796
68	92	1429	70	73	191*	71	92	1706*	73	79	4133*	74	101	3597
68	93	2349	70	74	139	71	93	769*	73	80	1049	74	102	6837
68	94	1106	70	75	621*	71	94	573	73	81	2061	74	103	490*
68	95	1056	70	76	1167	71	95	530	73	82	5504*	74	104	2862*
68	96	281	70	77	1786	71	96	5410	73	83	9863			
68	97	1353	70	78	121	71	97	2738	73	84	3498*	75	75	10000
68	98	1075	70	79	1405*	71	98	1581*	73	85	1033*	75	76	150*
68	99	891	70	80	38*	71	99	102*	73	86	3105	75	77	272*
68	100	2257*	70	81	1761*	71	100	1769	73	87	621	75	78	1592
68	101	1352*	70	82	1374	71	101	1445*	73	88	1017	75	79	2206
68	102	2382*	70	83	257*	71	102	1442*	73	89	3720*	75	80	153*
68	103	1749*	70	84	1903*	71	103	1549	73	90	560	75	81	1954
68	104	2913	70	85	364	71	104	3427*	73	91	1810*	75	82	982
			70	86	1780*				73	92	1444	75	83	982*
69	69	10000	70	87	1937*	72	72	10000	73	93	1541*	75	84	1261
69	70	1372	70	88	348*	72	73	1750	73	94	1081*	75	85	484*
69	71	3180*	70	89	1213*	72	74	2359*	73	95	2108*	75	86	702*
69	72	2946	70	90	598	72	75	2439*	73	96	1687*	75	87	962*
69	73	727	70	91	1572	72	76	384	73	97	2710*	75	88	1197*
69	74	3662*	70	92	170*	72	77	335*	73	98	671*	75	89	632
69	75	3428*	70	93	1097	72	78	-1235*	73	99	307	75	90	2704
69	76	1261	70	94	1689*	72	79	20*	73	100	328	75	91	443
69	77	939*	70	95	1946*	72	80	1349*	73	101	5057	75	92	2351*
69	78	218	70	96	1317*	72	81	1270*	73	102	7589	75	93	91*
69	79	1618	70	97	861*	72	82	1982	73	103	1536*	75	94	2035
69	80	850*	70	98	272	72	83	2098	73	104	385*	75	95	2309
69	81	67	70	99	1275	72	84	1748*				75	96	2595
69	82	98	70	100	1542*	72	85	3558*	74	74	10000	75	97	1646*
69	83	291	70	101	394*	72	86	2842*	74	75	1820	75	98	3085*
69	84	852	70	102	759*	72	87	698	74	76	969	75	99	298
69	85	1619*	70	103	2851*	72	88	3143*	74	77	3365	75	100	469
69	86	913*	70	104	3392	72	89	885*	74	78	1228	75	101	1665*
69	87	2337*				72	90	526*	74	79	3258*	75	102	61
69	88	2053*	71	71	10000	72	91	756	74	80	122	75	103	2103
69	89	1164	71	72	5304*	72	92	1635	74	81	2694*	75	104	1682*
69	90	2591*	71	73	5409*	72	93	741*	74	82	439			
69	91	2662	71	74	4299	72	94	3363*	74	83	4089	76	76	10000
69	92	2316	71	75	2147	72	95	2201*	74	84	1487*	76	77	992
69	93	3424	71	76	791*	72	96	2842*	74	85	2065	76	78	401*
69	94	1041	71	77	1177	72	97	3285*	74	86	1496	76	79	472*
69	95	1218	71	78	2424	72	98	1143*	74	87	878	76	80	463*
69	96	2208*	71	79	1700	72	99	2469*	74	88	3163	76	81	2925*
69	97	57*	71	80	1886*	72	100	1359*	74	89	3499*	76	82	380*
69	98	827	71	81	3076*	72	101	3058*	74	90	887	76	83	1403
69	99	1222*	71	82	4010	72	102	702*	74	91	104*	76	84	3724*
69	100	1499*	71	83	5237*	72	103	4595*	74	92	537*	76	85	249*
69	101	2164*	71	84	2587	72	104	565	74	93	2328*	76	86	3255*
69	102	2699*	71	85	2651				74	94	1410*	76	87	1303
69	103	3021*	71	86	323	73	73	10000	74	95	1297*	76	88	459*
69	104	2832	71	87	1000	73	74	3785	74	96	3962	76	89	1812*
			71	88	1549	73	75	1394*	74	97	494*	76	90	2193

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
76	91	1252*	78	88	286*	80	89	2452	82	94	830*	84	103	423
76	92	2072*	78	89	1647	80	90	162*	82	95	418	84	104	772*
76	93	104*	78	90	810*	80	91	183	82	96	1308			
76	94	125*	78	91	2969	80	92	396*	82	97	1986	85	85	10000
76	95	330	78	92	1098*	80	93	4655*	82	98	1267	85	86	3740
76	96	757*	78	93	3638*	80	94	3823*	82	99	1458*	85	87	157*
76	97	1881*	78	94	1019	80	95	2037*	82	100	320*	85	88	5718
76	98	1549*	78	95	1404	80	96	5639*	82	101	3571*	85	89	932*
76	99	614*	78	96	460*	80	97	3817*	82	102	3581*	85	90	3488
76	100	3593*	78	97	350*	80	98	1218	82	103	272*	85	91	3479*
76	101	134	78	98	5	80	99	1778	82	104	979	85	92	3018*
76	102	79	78	99	309	80	100	295*				85	93	1137*
76	103	1027	78	100	264	80	101	1187	83	83	10000	85	94	776*
76	104	443	78	101	1175	80	102	1297	83	84	3733*	85	95	762*
			78	102	1253	80	103	764	83	85	970*	85	96	253
77	77	10000	78	103	890*	80	104	1491*	83	86	2729	85	97	569
77	78	2447*	78	104	1979*				83	87	750	85	98	85*
77	79	1032*				81	81	10000	83	88	1068	85	99	2517
77	80	107	79	79	10000	81	82	4933*	83	89	3719*	85	100	3652
77	81	2265*	79	80	736	81	83	1925	83	90	995	85	101	5449
77	82	714	79	81	2237	81	84	2249	83	91	1921*	85	102	2421
77	83	604	79	82	2810	81	85	2928*	83	92	1329	85	103	1284
77	84	4	79	83	4075*	81	86	2436	83	93	1582*	85	104	329*
77	85	1455	79	84	3695	81	87	373*	83	94	1478*			
77	86	370	79	85	2869*	81	88	2865*	83	95	2201*	86	86	10000
77	87	1796*	79	86	1248*	81	89	2512	83	96	1703*	86	87	253*
77	88	2479	79	87	2040*	81	90	624	83	97	2809*	86	88	5204
77	89	340*	79	88	2899*	81	91	308	83	98	808*	86	89	1431
77	90	1655	79	89	5639	81	92	243	83	99	186	86	90	1756
77	91	963*	79	90	945*	81	93	304*	83	100	676	86	91	2894*
77	92	1461*	79	91	4247	81	94	1009	83	101	4800	86	92	324*
77	93	749*	79	92	1879*	81	95	276*	83	102	7711	86	93	663*
77	94	865*	79	93	866*	81	96	107*	83	103	1346*	86	94	1176*
77	95	1085*	79	94	316	81	97	1359	83	104	489*	86	95	3762*
77	96	2917	79	95	207	81	98	957				86	96	212
77	97	1495*	79	96	1146	81	99	2002*	84	84	10000	86	97	597
77	98	3422*	79	97	1005	81	100	1080	84	85	2365*	86	98	413
77	99	794	79	98	563*	81	101	911*	84	86	1155	86	99	1722
77	100	1015*	79	99	613	81	102	51*	84	87	485*	86	100	6517
77	101	2213	79	100	1068*	81	103	1242*	84	88	1121*	86	101	3972
77	102	2494	79	101	5463*	81	104	588*	84	89	4099	86	102	4224
77	103	1233*	79	102	3887*				84	90	340*	86	103	541
77	104	1481*	79	103	967*	82	82	10000	84	91	1426	86	104	1685*
			79	104	1614*	82	83	5207*	84	92	2240*			
78	78	10000				82	84	598	84	93	1846	87	87	10000
78	79	2672	80	80	10000	82	85	748	84	94	1338	87	88	555*
78	80	971	80	81	2128	82	86	1681*	84	95	707	87	89	641*
78	81	154*	80	82	1922*	82	87	236*	84	96	911	87	90	293*
78	82	401	80	83	984	82	88	1026*	84	97	881	87	91	1892*
78	83	442	80	84	56*	82	89	1556	84	98	449*	87	92	374*
78	84	2007*	80	85	463	82	90	1369	84	99	1199*	87	93	76*
78	85	2071	80	86	985	82	91	1284	84	100	609	87	94	797
78	86	457*	80	87	4884*	82	92	1076*	84	101	3056*	87	95	914*
78	87	468*	80	88	2810	82	93	1684	84	102	2698*	87	96	2794

Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)	Var. (A)	Var. (B)	Corr. Coef. (r)
87	97	610	90	90	10000	93	93	10000	97	97	10000
87	98	1596*	90	91	5414*	93	94	3168	97	98	5944
87	99	3054*	90	92	7504*	93	95	2035	97	99	49*
87	100	1245	90	93	1129	93	96	697	97	100	1602*
87	101	[illegible]32*	90	94	387*	93	97	2040	97	101	243*
87	102	1464	90	95	387*	93	98	1054	97	102	2592*
87	103	308*	90	96	175*	93	99	1301*	97	103	1964
87	104	531*	90	97	279*	93	100	-1271	97	104	71*
			90	98	434	93	101	411*			
			90	99	613*	93	102	2908*	98	98	10000
88	88	10000	90	100	1436	93	103	863	98	99	1430
88	89	1896	90	101	2559	93	104	6980	98	100	2357*
88	90	323*	90	102	777				98	101	1305
88	91	323*	90	103	1340	94	94	10000	98	102	2931*
88	92	1255	90	104	894	94	95	8711	98	103	2462
88	93	2352*				94	96	3416	98	104	1685
88	94	791*	91	91	10000	94	97	5240			
88	95	1328*	91	92	2497	94	98	1687	99	99	10000
88	96	238*	91	93	963*	94	99	296*	99	100	93
88	97	299*	91	94	2527	94	100	2287*	99	101	720
88	98	27*	91	95	3117	94	101	741	99	102	835
88	99	2505	91	96	3028	94	102	2299*	99	103	2873
88	100	3310	91	97	1928	94	103	1918	99	104	929
88	101	5494	91	98	1245*	94	104	613*			
88	102	4005	91	99	2195*				100	100	10000
88	103	2431	91	100	2817*	95	95	10000	100	101	1103
88	104	3242*	91	101	3136*	95	96	2153	100	102	2376
			91	102	1336*	95	97	4173	100	103	154
			91	103	1308*	95	98	1827	100	104	39*
89	89	10000	91	104	1938*	95	99	1611*			
89	90	752*				95	100	3399*	101	101	10000
89	91	2177				95	101	200*	101	102	6408
89	92	275	92	92	10000	95	102	3309*	101	103	1124
89	93	266*	92	93	569	95	103	1366	101	104	308*
89	94	164*	92	94	930	95	104	820*			
89	95	1128*	92	95	558				102	102	10000
89	96	1314*	92	96	1025*	96	96	10000	102	103	47*
89	97	768	92	97	1938	96	97	4247	102	104	1406*
89	98	1796	92	98	2318	96	98	3935*			
89	99	953*	92	99	985	96	99	1403*			
89	100	685	92	100	364*	96	100	133	103	103	10000
89	101	1440*	92	101	1244*	96	101	1151*	103	104	628
89	102	2725*	92	102	207*	96	102	768			
89	103	854	92	103	171*	96	103	68*			
89	104	1733*	92	104	153*	96	104	2371*	104	104	10000

APPENDIX V

COMPARISON OF ASTRONAUT AND NON-ASTRONAUT PERFORMANCE

	$\overline{X}_A$	$\overline{X}_N$	s^2_A	s^2_N	F	t
1	7.6	6.5	.36	.78	2.16	3.0
2	7.4	7.1	.36	.34	1.05	1.2
3	7.0	6.3	.33	.65	1.96	2.1
4	7.4	6.8	.36	.65	1.80	1.8
5	7.3	6.9	.41	.47	1.14	1.4
6	7.3	6.8	.75	.52	1.44	1.5
7	7.1	6.7	.51	.56	1.09	1.2
8	7.7	7.1	.75	.69	1.08	1.6
9	7.1	6.8	.85	.78	1.08	.7
10	7.6	6.9	.36	.82	2.27	1.9
11	7.1	6.9	.18	.43	2.38	.7
12	7.4	6.9	.36	.83	2.31	1.4
13	7.0	7.1	.66	.52	1.26	.3-
14	6.7	6.8	.41	.52	1.26	.3-
15	7.4	6.7	.36	.56	1.55	2.2
16	35.1	31.8	13.85	46.00	3.32	1.2
17	36.0	31.2	18.33	52.91	2.88	1.6
18	29.9	28.6	22.85	59.47	2.60	.4
19	14.4	14.8	4.03	2.65	1.52	.5-
20	18.6	17.1	.70	3.86	5.51	1.9
21	16.0	15.3	1.33	1.82	1.36	1.2
22	15.7	13.8	1.08	2.69	2.49	2.8
23	15.3	15.3	5.75	5.43	1.05	0-
24	17.0	16.3	2.00	3.73	1.86	.8
25	13.7	13.4	3.08	5.21	1.69	.3
26	15.6	14.7	2.70	5.30	1.96	.9
27	15.0	14.8	1.33	3.47	2.60	.2
28	12.6	13.9	2.70	4.39	1.62	1.5-
29	13.4	13.4	3.36	7.47	2.22	0-
30	11.7	11.6	2.08	4.95	2.37	.1
31	15.6	15.0	14.36	4.86	2.95	.5
32	21.4	20.3	5.03	11.86	2.35	.7
33	21.7	20.8	4.08	7.47	1.83	.8
34	32.0	31.0	242.66	330.65	1.36	.1
35	90.0	86.5	77.33	69.39	1.11	.9
36	39.0	37.5	24.00	302.69	12.61	
37	31.7	36.5	160.41	91.21	1.75	1.0-
38	4.3	5.3	3.41	4.82	1.41	1.0-
39	2.9	3.2	-10.51	3.65	2.87	.3
40	16.1	14.7	45.85	44.91	1.02	.4

	$\overline{X}_A$	$\overline{X}_N$	S^2_A	S^2_N	F	t
41	.9	.9	2.51	3.00	1.19	0-
42	3.6	3.1	3.70	3.65	1.01	.6
43	1.6	1.4	1.70	1.65	1.03	.3
44	4.0	4.8	6.00	11.04	1.84	.5-
45	3.9	2.5	8.51	6.08	1.39	1.2
46	36.1	35.0	64.18	60.47	1.06	.3
47	0	.1	0	.08		1.0-
48	1.9	1.4	2.85	1.34	2.12	.9
49	19.3	18.1	29.08	22.94	1.27	.6
50	16.9	22.3	41.51	19.73	2.10	2.5-
51	31.1	33.8	33.18	18.72	1.77	1.3-
52	19.1	21.3	44.18	14.78	2.98	1.1
53	30.0	32.1	39.66	30.81	1.29	.8-
54	36.1	36.0	16.85	22.47	1.33	.1
55	77.3	68.4	195.30	108.81	1.79	1.7
56	57.3	54.1	673.12	278.23	2.42	.4
57	1494.1	1490.9	1366.18	2282.65-	1.67	.1
58	313.1	307.5	174.51	344.34	1.97	.7
59	289.6	288.3	265.03	200.95	1.31	.2
60	242.9	246.8	330.85	119.30	2.77	.7
61	212.9	217.4	471.85	230.69	2.04	.6-
62	972.0	966.0	862.66	2011.86	2.33	.3
63	323.1	329.9	145.51	472.39	3.24	.7-
64	391.7	410.9	431.08	291.78	1.47	2.4-
65	1477.0	1410.0	8124.66	11523.62	1.42	1.5
66	523.3	523.5	109.08	85.47	1.27	0-
67	517.6	517.1	55.70	121.47	2.18	1
68	776.7	804.6	3921.41	2599.82	1.50	1.2-
69	734.9	754.7	3185.18	2266.60	1.40	.9-
70	112.9	111.8	54.85	44.82	1.22	.3
71	123.9	125.0	10.51	14.08	1.33	.7-
73	166.7	161.4	221.08	190.69	1.15	.8
74	1764.7	1749.6	1317.75	2071.13	1.57	.8
75	49.6	52.7	106.03	71.60	1.48	.8-
76	389.6	403.2	25193.36	40558.00	1.60	.1-
77	84.9	86.7	139.51	355.43	2.54	.2-
78	10.0	10.2	19.33	19.78	1.02	.1-
79	104.7	113.0	68.12	100.00	1.47	1.7-
80	124.9	126.1	111.27	162.52	1.46	.2-
81	53.7	57.3	235.12	185.66	1.27	.5-
82	1006.3	1008.5	3.61	25.04	6.94	1.0-
83	77744.0	73480.0	60051512.00	44329932.19	1.35	1.3
84	47.4	48.0	62.70	65.69	1.04	.1-
85	571.4	516.1	2125.70	2500.65	1.17	2.6

	$\overline{X}_A$	$\overline{X}_N$	S^2_A	S^2_N	F
86	[illegible]	[illegible]	[illegible]	[illegible]	5.63
87	[illegible]	20.0	[illegible]	182.22	4.00
88	[illegible]	73.0	[illegible]	[illegible]	1.72
89	[illegible]	[illegible]	[illegible]	[illegible]	1.89
90	7.4	3.0	7.16	[illegible]	4.56
91	[illegible]	29.0	[illegible]	291.49	1.32
92	0	.3	0	.17	
93	4.9	3.9	[illegible]	22.16	5.99
94	6.0	[illegible]	[illegible]	32.25	9.68
95	2.9	[illegible]	[illegible]	21.30	4.24
96	[illegible]	[illegible]	[illegible]	1994.49	1.81
97	134.7	[illegible]	[illegible]	2266.40	1.14
98	[illegible]	147.4	[illegible]	2908.40	1.83
99	[illegible]	[illegible]	[illegible]	4368.86	2.91
100	[illegible]	176.1	[illegible]	322.65	4.36
101	[illegible]	[illegible]	164.90	270.17	1.60
102	667.7	[illegible]	2102.41	2201.13	1.04
103	34.7	37.9	20.41	227.17	11.13
104	7.7	6.6	20.41	17.65	1.49

Legend

$\overline{X}_A$ = mean score of the Mercury Astronauts

$\overline{X}_N$ = mean score of the Non-Astronauts

S^2_A = the variance of the Mercury Astronauts

S^2_N = the variance of the Non-Astronauts

F = the ratio of the variances

t = the probability of statistical difference