RESTRICTED Not for publication

TESTS OF THE "ABILITY TO TAKE IT"

by
Jack W. Dunlap

with the assistance of

J. W. Howland
J. D. Coakley
E. A. Lipman
F. Gehmann
K. J. O'Neil
L. S. Kogan

A report on research conducted at the University of Rochester, Rochester, New York, by means of a grant-in-aid from the National Research Council Committee on Selection and Training of Aircraft Pilots from funds provided by the Civil Aeronautics Administration.

February 1943

CIVIL AERONAUTICS ADMINISTRATION
Division of Research
Report No. 11
Washington, D. C.

National Research Council

Committee on Selection and Training of Aircraft Pilots

Executive Subcommittee

C. W. Bray

D. R. Brimhall

L. A. Carmichael

J. W. Dunlap

J. C. Flanagan

H. M. Johnson

W. R. Miles

G. R. Wendt

M. S. Viteles, Chairman

LETTER OF TRANSMITTAL

NATIONAL RESEARCH COUNCIL

2101 Constitution Avenue, Washington, D. C.
Division of Anthropology and Psychology

Committee on Selection and Training of Aircraft Pilots

February 26, 1943

Dr. Dean R. Brimhall
Director of Research
Civil Aeronautics Administration
Washington, D. C.

Dear Dr. Brimhall:

The attached report, entitled Tests of the "Ability to Take It" embodies results of investigations conducted at the University of Rochester by Jack W. Dunlap and his staff, under a grant from the Committee on Selection and Training of Aircraft Pilots. The report is submitted with the approval of the Committee, with the recommendation that it be included in the series of technical reports issued by the Division of Research, Civil Aeronautics Administration.

While the report includes only results obtained at the University of Rochester, there are references to materials and findings of parallel research conducted elsewhere. In particular, note is made of a statistical analysis of "ability to take it" tests by Robert J. Wherry, University of North Carolina. The results of this analysis are presented as Supplement I to the attached report. The findings of investigations on similar tests, conducted by A. R. Gilliland, Northwestern University, will appear as a separate report.

The chief outcome of the investigation by Dr. Dunlap is the conclusion that two of the tests are sufficiently reliable for use in investigating the possibility of predicting the capacity of pilots and of other military personnel to resist pain and fatigue. It is also important to note that the investigation has included an evaluation of several measures which have been discarded for various reasons as being unsuitable for future research. There still remains the problem of designing and conducting an experiment, involving adequate criteria of performance under stress, which may furnish evidence on the validity of these tests for predicting the "ability to take it" of pilots or of other military personnel.

Very truly yours,

Morris S. Viteles, Chairman
Committee on Selection and
Training of Aircraft Pilots
National Research Council

MSV:rm

TABLE OF CONTENTS

SUMMARY

There is a popular belief that a successful flyer must be able to 'take it' -- to endure conditions so painful and so fatiguing that the average person would give up. The present study was undertaken to learn whether measures of such an ability could be found which were reliable enough to justify validating them in the field.

Nine tests went through a preliminary trial on about thirty individuals. This trial served to show the best methods of administration, to locate faults in the apparatus, and to eliminate dangerous or impractical tests. Five of the nine tests were discarded on the basis of the results of these preliminary investigations.

The four tests retained for the main study were administered to 129 men in 1941. Two of the tests required the subject to withstand pain; the other two to withstand fatigue:

(1) Electric shock. Vibratory shock was administered to each hand at a constantly increasing rate. The subject reported when he first felt any sensation; when he first felt pain; when the shock was 'very painful'; and when he could stand no more.

(2) Wedge penetration apparatus. A brass wedge was set with its axis parallel to the bones of the subject's palm and gradually screwed down. Readings at three points during the increasing pressure (thickness of the hand, point of first pain sensations, and the terminal point at which the subject demanded to be released) furnished a single index score.

(3) Hand dynamometer. The subject's maximum grip (best pull in three trials) was determined for each hand. Then he was required to maintain a grip above a point equal to 60% of his maximum. The time he was able to maintain this grip was recorded.

(4) Chest Ergometer. The subject grasped two handles attached to either end of a strong spring, and, holding them at arms length, pulled them apart. After his maximum pull (best in three trials) had been determined, the instrument was set at 50% of this maximum. He was then required to maintain his pull as long as possible above this 50% point.

The 1941 data yielded intercorrelations among 22 raw scores and indices, and reliabilities as measured by correlations between the right and left hands. There were substantial correlations among the 'strength' measures, but little among the measures of resistance to pain or fatigue. Reliabilities were highest for the shocker and dynamometer.

Measurements on the shocker and the hand dynamometer were repeated on 75-85 of the subjects after an interval of approximately ten months. These tests furnished 18 raw scores and indices whose test-retest reliabilities were studied.

Ten of the most reliable measures (1941 data) were selected for factor analysis. Four factors were found and interpreted as: (1) apprehension, (2) endurance of pain, (3) momentary strength, and (4) willingness to exert oneself. These results show a large measure of agreement with an analysis of similar tests by Wherry.

On the basis of this study two measures are recommended for validation in the field: the greatest amount of shock a person can take (the estimated reliability of the sum of two measures from each hand is about .91); and the amount of time a person can maintain his grip at 60% of his maximum gripping strength (the estimated test-retest reliability of the sum of two measures with his preferred hand is about .60).

The wedge test and the chest ergometer are not recommended, at least for the present, in view of mechanical difficulties and possible danger to the subject.

INTRODUCTION

There is a popular belief that a successful flier should be able to 'take it' — to endure degrees of pain, cold, anoxia, etc. beyond the capacity of the average man. This belief has found some support in the records of German military psychologists and in the practices employed by them in the selection of combat pilots.[1]

While recognizing the experimental difficulties to be encountered, the Committee on Selection and Training of Aircraft Pilots, feeling that no lead should be overlooked in the selection of our combat pilots, has sponsored a number of investigations involving so-called tests of 'ability to take it.'[2] The experiment described in this report is one of a series of such projects.

The primary purpose of this experiment was to determine whether or not a battery of reliable measures of resistance to pain and fatigue could be constructed with the anticipation that such tests could then be submitted to validation under practical flying conditions with the view of verifying or refuting the popular belief concerning the relationship between 'ability to take it' and performance as a pilot. The latter step has not yet been taken, but in this report is found evidence concerning the reliability of measures tentatively designated as 'ability to take it' tests.

[illegible]

The study to be reported here was divided into three experimental phases: (A) the preliminary phase, (B) the 1941 studies, and (C) the 1942 repeat tests.

A. The Preliminary Phase.

The chief aim of this phase of the study was to determine which instruments and techniques could be used in the final studies of pain and fatigue. Several conditions were set forth for any technique or apparatus to be included in the final test battery:

(a) Simplicity of design.
(b) Inexpensiveness.
(c) Mobility.
(d) Ease of [illegible]
(e) Short [illegible]
(f) [illegible]

---

[1] Hesse, K. Die [illegible] (... [illegible]) Industr. Psychotech., 1930, [illegible]

Schmidt, H. Gesamtpersönlichkeitsanalyse von [illegible] nach Leistung und Verhalten. (Analysis of the Whole Personality of [illegible] Flyers on the Basis of Performance and Behavior.) Industr. Psychotech., [illegible], 15, [illegible]-235.

[2] While the phrase 'ability to take it' [illegible]

Preliminary tryout of the nine tests[3] listed below was conducted on the staff and a miscellaneous group of thirty individuals. This tryout was utilized to determine the best methods of administration, to locate faults in the apparatus, to establish limits beyond which a subject was not to be permitted to go, and to eliminate dangerous, impractical, or superfluous tests. A physician was present throughout these tests.

(a) The radiant heat test.
(b) Immersion of the hand in ice water.
(c) 'Dry' and 'wet' electric shock.
(d) Wedge penetration test.
(e) The Smedley hand dynamometer.
(f) Maintaining the arm perpendicular to the body.
(g) Maintaining the leg perpendicular to the body.
(h) A modified Mosso finger ergometer.
(i) A chest ergometer.

Tests c (wet shock), d (wedge test), e (hand dynamometer), and i (chest ergometer) were retained to appear in the final battery. All others were eliminated for reasons given in Appendix A. Standardized procedures and techniques of administration for the retained tests were set up and the first experimental studies (1941) begun.

B. The 1941 Studies.

Two pain-producing devices, the shocker and the wedge penetration apparatus, and two fatigue-producing devices, hand dynamometer and chest ergometer, were employed in these studies.

The main investigation was performed on 179 subjects, most of whom were male students at the University of Rochester, the others being men enrolled in the local C.P.T. introductory course. However, complete data on all of the measures were obtained for only 129 cases, of which 119 were University of Rochester students and 10 were C.P.T. men. All the data were secured in April and May of 1941.

Twenty-two scores or indices were obtained for each of 129 students. All of these scores were intercorrelated, yielding 231 intercorrelations as indicated in Table I. The mean and standard deviation of each score or index, were likewise computed. Maximum and minimum scores for each test, indicating the ranges covered, are given in Table II.

Further studies were made using correlations between the measures taken on the right and left hands as indices of reliability of the instruments and techniques employed.

---

[3] Complete descriptions of tests (c), (d), (e), and (i) appear in the text. The rest are described in Appendix A along with reasons for their elimination from the experimental battery.

A physician was present throughout the testing. In the early part of the study a short medical history was secured from each subject. Blood pressure, pulse, and other physiological measures were recorded.[4] No analyses were made of these latter measures.

C The 1942 Studies.

Due to limitations of time in the spring of 1941, it was impractical to attempt to secure retest measures on the subjects. After the main body of the data had been analyzed, it seemed advisable to secure such data on the dynamometer and on the constant stimulus shocker.

Retesting of the 1941 subjects was begun in February, 1942, about ten months after the completion of the previous study. At that time 89 of the University students with complete test records and a number of students with incomplete records were still in school. The ten C.P.T. students had completed their course and were not available. At the conclusion of the 1942 testing, scores for 1941 and 1942 were available for the following numbers of subjects:

(a) 85 students on the constant stimulus shocker.
(b) 79 on the maximum dynamometer grip.
(c) 77 on the dynamometer time for the right hand.
(d) 75 on the dynamometer time for the left hand.

Fourteen available cases were left untested. Some refused point-blank to be retested, but most of them simply failed to appear for the tests at the appointed time.

These test-retest data yielded reliability coefficients and coefficients of relative variability.

APPARATUS AND ADMINISTRATION OF THE TESTS.[5]

The tests used in the final battery are modifications of techniques of studying pain and fatigue already well known in psychological experimentation. Because of some of these modifications the tests actually used in the study are described in some detail below:

---

[4] Dr. J. D. Howland was the attending physician. Dr. Dunlap and Mr. K. O'Neil were responsible for administering the electric shock; Mr. F. Gehlmann for the wedge penetration test; Dr. E. A. Lipman for the hand dynamometer tests; and Mr. L. S. Kogan for the chest ergometer. Dr. J. D. Coakley who designed and built the constant stimulus shocker, helped in the maintenance of the apparatus.

Statistical work on the data obtained was done under the direction and supervision of Dr. Dunlap, assisted by Mrs. C. Harper and Mr. L. S. Kogan.

[5] A manual for administration of the tests, specifications for construction of the constant stimulus shocker, and a comparison of the micrometer wedge test with the Howells wedge pressure test may be found in the Appendices.

Pain-Producing Devices

(1) Electric Shock. The constant stimulus shocker is contained in a 10 x 8 x 7 1/2 inch metal box. It furnishes a current varying from 0.0 to 3.56 milliamps when connected with a 110-volt source. This current is transformed in a 500-volt transformer and is passed through a rectifying tube with the appropriate resistances in the various circuits. One electrode is immersed in one beaker of saturated salt solution and another electrode in a second beaker. The subject completes the circuit by inserting two fingers of the same hand in the two beakers.[6] (See Fig. 1.)

The instrument is scaled in terms of peak current rather than average current so that the scale values which range from 0 to 96 should be divided by $2\sqrt{2}$ to secure the unit (milliamps) commonly used in measuring current. A scale on the front panel of the instrument indicates the amount of current used. A false rider is carried by the adjusting knob of the rheostat and indicates the maximum point reached by the subject. The examiner practiced turning the knob at the rate of one full turn each sixty seconds.

In the course of the testing the candidate reports four stages of experience as the examiner turns the dial at a slow, constant speed:

(a) When he first feels anything at all.
(b) When he first feels pain (P).
(c) When the shock is 'very painful,' but he can stand more (VP).
(d) The terminal point, when he calls for the current to be cut off (T).

Since the point at which the subjects reported that they first felt anything was relatively stable (5-7 on the scale), this score was not used in the final analysis. Three raw scores were obtained from which four indices were computed for each hand:

(a) Terminal point minus 'painful point' -- $T-P$.
(b) The ratio of the difference between the terminal point and the 'painful point' to the terminal point, $(T-P)/(T)$.
(c) The ratio of the difference between terminal point and the 'very painful point' to the difference between the terminal point and the 'painful point,' $(T-VP)/(T-P)$.
(d) The ratio of the difference between the terminal point and the 'very painful point' to the 'very painful point,' $(T-VP)/(VP)$.

---

[6] Usually the first and second fingers were used for the test. Occasionally an individual was found who had a cut, abrasion, or hang-nail on one or more of these fingers. Such an individual would report sensations at a much lower point than he would normally. The hands of all those to be tested were therefore carefully examined and, if defects were found on the index fingers, other fingers were selected. Minor cuts can be protected by collodion.

Front Rear

FIGURE 1.

Constant Stimulus Shocker

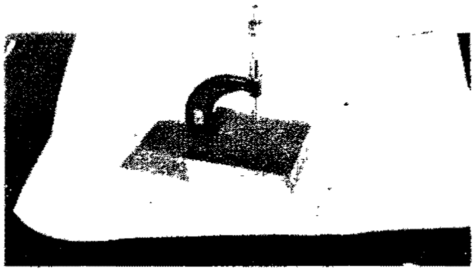
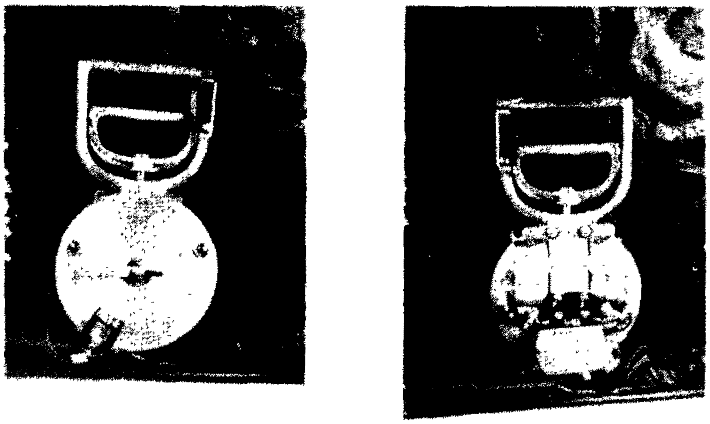


FIGURE 2.

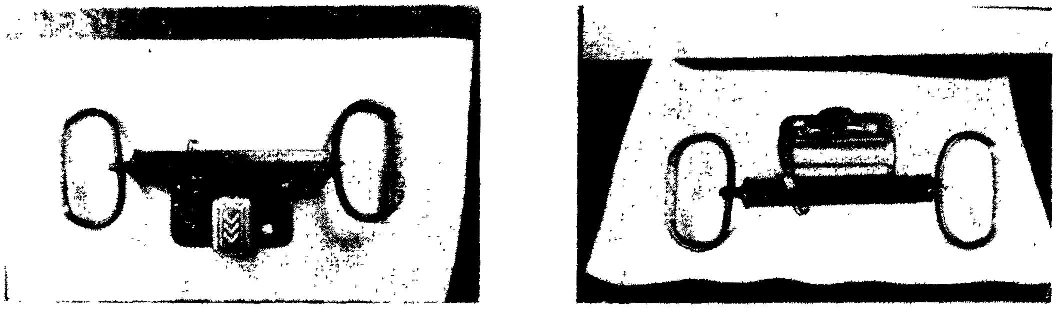
Wedge Penetration Apparatus



Front Rear

FIGURE 3.

Hand Dynamometer



Front Rear

FIGURE 4.

Chest Ergometer

This test is administered by two persons, one operating the instrument and the other recording the scores. The subject was blind-folded by means of goggles throughout the test and was told not to remove his fingers from the salt solution at any time. The blindfold served to concentrate the subject's attention, and many individuals reported dislike of wearing the goggles since they could not see, and thus were apprehensive. The entire test for both hands takes about 5 to 7 minutes.

(2) The Wedge-Penetration Apparatus. This apparatus, modified from Howells,[7] consists of a three-inch "click" micrometer calibrated in thousandths of an inch and attached to a wooden block. A brass wedge with a blunt but highly polished penetrating surface is slipped on the end of the micrometer screw. (See Fig. 2.)

The subject places his hand, palm up, on the block. The wedge is then set on the palm with its long axis parallel to the bones of the hand. By means of the micrometer screw it is then forced down between the second and third metacarpals by the experimenter. The operator turns the screw until a ratchet spring 'gives.' Records are taken at this point as a measure of the thickness of the subject's hand — (I). The experimenter continues to turn the micrometer screw at a slow, constant speed. The subject reports: first, when he feels pain - (P); second, the terminal point, when he demands to be released - (T).

Three raw scores are recorded for each hand: (a) thickness of the hand, (b) pain point, (c) terminal point. These data furnish an index for each hand. This index is the ratio of the difference between the pain point and the terminal point to the total penetration of the hand from the initial to the terminal point --- $(T-P)/(T-I)$.

One person administers the test. It takes about 5 minutes to test each hand and a rest period of at least 10 minutes is allowed between trials.

<u>Fatigue-Producing Devices</u>[7a]

(1) <u>The Hand Dynamometer</u>. A Smedley hand dynamometer, modified to yield a measure of force and time in terms of sustained grip above a point proportional to the maximum grip, was employed in this study.

Two batteries are attached to the back of a standard Smedley hand dynamometer. These batteries supply the current for an adjustable buzzer, a red light, and an amber light attached to the dial face of the instrument. A small attachment on the face of the dial makes it possible to vary the positions at which the buzzer, the red light, and the amber light are activated. The relations of the buzzer and the two lights never vary among themselves, but the three, as a unit, can be shifted to any position on the dial. A complete circuit is formed through a false rider which moves forward with the indicator hand. Thus, if the attachment is set at thirty units on the dial, the buzzer will sound when the indicator hand shows a grip of thirty kilograms,

---

[7] Howells, T. H. An experimental study of persistence. <u>J. abnorm. (soc.) Psychol.</u>, 1933, 28, 14-29.

[7a] For descriptions of standard fatigue-producing devices, see: Bills, A. G. General Experimental Psychology New York: Longmans, Green, 1934.

the red light will come on at 32-34 kilograms, and the amber light at 35-37. In the present experiment an extra attachment recorded on a kymograph and waxed paper the number of times the light flickered from red to amber.[8] (See Fig. 3.)

Each subject was asked to exert his maximum grip on three successive trials, first with one hand and then with the other. After the maximum grips for the entire group had been obtained in this manner the fatigue test was given to the subjects individually. (See Appendix E.)

The experimenter set the buzzer to sound at 60% of the maximum grip of the subject being tested (maximum grip being the strongest pull in the three trials on the hand tested). The subject's task was to keep the indicator hand of the dynamometer above this point so that the amber light remained on. He was not to allow the instrument to touch his body at any time. The red light flashed on as a warning to the subject that he was relaxing his grip. The buzzer was the signal that the test was over for that hand. The examiner recorded the total time for each hand from the starting point until the sound of the buzzer. At least ten minutes intervened between hands.

One examiner gives this test, taking approximately three minutes for each hand. He records two scores for each hand: (a) Maximum grip in kilograms and (b) total time the subject stayed above 60% of his maximum grip.

(2) <u>The Chest Ergometer</u>. This instrument is essentially a spring which is to be pulled apart by two handles. The force of the pull is registered on a point scale ranging from 0 to 50. A buzzer, a white light, and a red warning light are attached as on the dynamometer. (See Fig 4.)

The subject grasps the two handles, palms facing, and keeps the instrument, at arms length with his elbows straight, directly in front of his eyes. He then pulls outward on the handles as hard as possible without raising or lowering his arms or allowing the instrument to go to one side. Three trials are given. The best pull out of the three is called the individual's maximum pull. When all of the subjects have been tested for their maximum pulls in this manner, the individual testing is begun. This procedure provides a minimum rest period of 10 minutes for each subject.

In the individual fatigue tests the buzzer is set at 50% of the maximum pull previously determined for that subject. The directions to the subject are similar to those given for the hand dynamometer. (See Appendix E.)

One person can administer the test taking about five minutes for each subject. Two scores are used in the final record: (a) The maximum pull (best in three trials), and (b) the total time that the subject maintains a pull above 50% of his maximum.

---

[8] This latter attachment was used in hope of learning whether the more steady subjects were also the more persistent. It was found that the 'flickers' (steadiness) had no relation to the time the subject was able to maintain his grip. As the results showed no promise, the attachment was discarded.

RESULTS

Intercorrelations of the 22 measures and indices and the means and standard deviations for the 1941 cases (N = 129) are presented below in Table I. The maximum and minimum scores for the measures used in the final analysis, indicating the ranges covered, are listed in Table II. Tables III, IV, V, and VI present further analyses of the 1941 data and comparisons of this data with the retest scores collected in the 1942 study.[9]

A. Studies of Reliability. Measures of reliability for the wedge penetration test, the electric shock, and the hand dynamometer were afforded in the 1941 study by the correlation between scores of the right and left hands. Subsequently, in 1942, retest data provided another method of establishing the reliability of two of these tests. The nature of the investigation in 1941 rendered retesting extremely difficult.

The left-right reliabilities range from .44 to .84. The reliability of the hand dynamometer for grip was .79 and for time .51. For the wedge penetration test it was .61. Measures of reliability were also computed for the various raw scores and indices of the constant stimulus shocker. These ranged from .30 to .84 for the raw measurements, and from .44 to .73 for the various indices. (Table I.)

There is considerable reason to believe that these correlations are attenuated due to the unwillingness or inability of the subject to exert himself on the second trial on the other hand after he had exerted himself on the first trial. This contingency appeared to be exceptionally likely for the fatigue tests. With respect to shock, moreover, many subjects were frightened by the apparatus on the first trial, but on the second trial overcame this initial fright and were able to go much further.

The subjects retested in 1942 showed obvious shifts in attitude and motivation in both the tests used in this study — the hand dynamometer and the constant stimulus shocker. Some of them had been attracted by the novelty of the tests in 1941, but were reluctant to take them again in 1942. Other subjects had to be encouraged in the 1941 testing to fight as hard as they could because of the presence of friends and the knowledge of the performance of others. In 1942, remembering the punishment taken, some were reluctant to repeat the tests. On the other hand, some of the subjects who did poorly in 1941 were anxious to improve their scores in the retest. In other words, it seems possible that a situation offering a more constant motivation and a more or less standard environment, such as the examination for flight training selection, would tend to increase the reliability of the tests.

---

[9] A crude attempt was also made to get indirect estimates of the validity of these tests. A brief summary of this study is reported in Appendix B.

TABLE II. RANGES OF SCORES AND INDICES ON PAIN-FATIGUE BATTERY

		Mean	S. D.	Minimum Score	Maximum Score
Chest Ergometer	Pull	27.25	4.33	16	46
	Time	47.26	16.03	14	107
Hand Dynamometer					
Right Hand	Grip	58.79	7.07	41	77
	Time	52.04	14.17	17	82
Left Hand	Grip	[illegible]	6.92	38	71
	Time	[illegible]	15.21	15	100
Wedge Penetration					
Right Hand	Index	26.28	11.64	4	61
Left Hand	Index	26.92	11.37	5	70
Shock					
Right Hand	Pain	20.09	10.16	7	68
	Very painful	34.68	13.93	10	90
	Terminal	56.07	19.02	11	96 (No. = 13)
	Index I*	35.98	14.79	10	77
Left Hand	Pain	20.83	9.89	8	68
	Very Painful	34.54	13.05	11	96 (No. = 1)
	Terminal	54.11	16.71	18	96 (No. = 10)
	Index I*	33.24	13.41	9	84

---

*Only Index I was retained, as it had the highest reliability.

TABLE III

	Means and Standard Deviations								Coefficient of Relative Variability*			
	Right Hand				Left Hand				Right Hand		Left Hand	
	Mean 1941	Mean 1942	S.D. 1941	S.D. 1942	Mean 1941	Mean 1942	S.D. 1941	S.D. 1942	1941	1942	1941	1942
[illegible]												
[illegible]	57.2	55.1	6.55	6.46	54.0	52.2	6.61	6.51	.11	.12	.12	.12
[illegible]	50.1	55.9	13.9	14.0	50.6	54.5	16.5	15.9	.28	.25	.32	.29
Rocker												
[illegible] (P)	21.8	[illegible]	[illegible]	10.0	22.3	16.1	11.3	8.3	.54	.60	.51	.52
[illegible] (VP)	[illegible]	[illegible]	[illegible]	15.8	36.1	27.4	15.7	11.6	.40	.54	.45	.43
[illegible] (T)	[illegible]	[illegible]	[illegible]	[illegible]	56.0	49.7	17.9	19.0	.35	.36	.32	.38
[illegible]	36.4	37.7	14.1	15.9	33.4	33.2	12.4	16.0	.39	.42	.37	.48
[illegible]	.64	.69	.12	.12	.60	.67	.13	.13	[illegible]	.17	.22	.19
[illegible]	.57	.59	.17	.19	.56	.62	.20	.17	.30	.32	.36	.25
[illegible]/VP	.66	.94	.41	.72	.68	.98	.51	.83	.62	.76	.75	.85

*Coefficient of Relative Variability = $\frac{\sigma}{M}$

In Table III the means, standard deviations, and coefficients of relative variability are given for all measures on the dynamometer and constant stimulus shocker for the individuals who had been tested twice. In general, the 1941 and 1942 distributions are comparable as to mean and standard deviation. In examining Table III, it will be noted that the points for pain, very painful, and terminal pain are slightly lower for the 1942 cases than for the 1941 subjects. This can be accounted for by the fact that the constant stimulus shocker was modified during the interim and had a slightly different calibration in 1942.

The test-retest correlations (1941 vs. 1942) are presented in Table IV below. In general, these correlations tend to be lower than the corresponding right-left correlations. It must be remembered, however, that the time interval in the former case (test-retest) was approximately 10 months, while in the latter (right-left correlations), only a matter of minutes. This factor alone would tend to reduce the correlations.

TABLE IV

Test-Retest Correlations for the Hand Dynamometer and the Constant Stimulus Shocker.

	Right-Left Correlations 1941	Right-Left Correlations 1942	Right Hand 1941 vs. 1942	Right Hand Prediction for two trials	Left Hand 1941 vs. 1942	Left Hand Prediction for two trials*
Dynamometer						
Grip	.79	.59	.71	.83	.69	.82
Time	.51	.49	.43	.60	.41	.58
Shocker						
Pain	.80	.79	.60	.75	.64	.78
Very Painful	.83	.81	.63	.75	.64	.78
Terminal	.84	.79	.78	.88	.74	.85
T-P	.73		.61	.76	.55	.71
(T-P)/T	.63		.31	.47	.37	.54
(T-VP)/(T-P)	.44		.31	.47	.30	.46
(T-VP)/VP	.58		.36	.53	.17	.29

*These correlations were calculated by the Spearman-Brown formula for a test of twice the length of the one used.

The maximum grip that an individual can exert has a test-retest reliability of .71 and .69 for the right and left hands respectively (Table IV). If two samples had been taken, the reliability, according to the Spearman-Brown formula would step up to .83 and .82 for the two hands, respectively. The length of time that the individual can maintain 2/3 of his maximum grip is of some importance for the [illegible] [illegible]. [illegible] its reliability is low, [illegible] [illegible] [illegible] the right and left hands, respectively. [illegible] for the right and left hands is shown [illegible] .60 and .58 for two trials.

on each hand. In using the dynamometer it is recommended that two trials be taken with the preferred hand and the average of the two be taken as the individual's ability to resist fatigue.

In Table V, the measures on the right and left hands have been combined additively and test-retest (1941 vs. 1942) correlations computed.

TABLE V

Right and Plus Left Hand
1941 vs. 1942

	Raw Scores	Corrected by Spearman-Brown
Shocker		
Painful	.67	.80
Very Painful	.72	.84
Terminal	.83	.91
Dynamometer		
Grip	.73	.84
Time	.46	.63

Of the various measures on the shocker, the most reliable, when the right-left and test-retest correlations are considered, is that of the terminal point, i.e., when the individual can go no further. Particular note should be made of the correlation between the sum of the terminal scores for the right and left hands for 1941 and 1942. This correlation is .83 and when stepped up by the Spearman-Brown formula becomes .91. This value is the best estimate that [illegible] of the reliability of [illegible] score for the [illegible] of the right and left hands. Thus, in practice, two trials should be given with both the right and the left hands, and the average taken as the individual's ability to resist pain.

In Table VI below are presented the test-retest correlations for the initial measures taken on the constant stimulus shocker when they are combined additively in various combinations.

TABLE VI

Test-Retest Correlations of the Combined Scores

	Right Hand 1941 vs. 1942	Left Hand 1941 vs. 1942
Constant Stimulus Shocker		
P + VP	.66	.70
VP + T	.77	.78
P + T	.78	.73
P + VP + T	[illegible]	.78

B *Intercorrelations.* A positive and substantial correlation was found between *strength* as measured by chest-pull and grip in the right and left hands, namely, .47 and .41. However, the correlations between measures of *fatigue* when recorded in terms of time for chest-pull and dynamometer grip were found to be in the neighborhood of .00 with all measures and indices of pain. The measures of strength and endurance appear to be independent of the ability to resist pain. The various measures of *wedge penetration* and *shock* are correlated with each other in general in the neighborhood of .25. This low correlation indicates that there may be difference between pain as induced by dull pressure and pain as induced by a 'vibratory' shock.

In general, the evidence indicates that the capacities "to take it" as measured by willingness to endure pain or fatigue have no relation to each other. This hypothesis finds further confirmation in the work of Wherry.[11] It must be remembered that all these measures were obtained in a highly motivated social situation which one might consider to be only a partial substitute for the sterner motivation of reality in the flying situation.

C *Factor Analysis.* Using Thurstone's Centroid Method of Factor Analysis,[12] the intercorrelations of 10 of the 22 measures employed in 1941 were studied (N = 129). Not all of the indices of shock were used in the factor analysis because of the spuriously high correlations between them. The presence of the same original scores in the formulae used in the calculation of these indices forces this high correlation. Those indices of shock having the highest reliability (defining reliability in this case as the correlation between measures on the right and left hands) were selected to appear in the factor analysis. The right-left reliabilities for these indices of shock as well as for the other variables to be factorized are listed below:

Measure	*Reliability* (right-left correlations)
Chest Ergometer ---------- Pull	---
Chest Ergometer ---------- Time	---
Dynamometer -------- Right Grip	.73
Dynamometer -------- Right Time	.51
Dynamometer --------- Left Grip	.79
Dynamometer --------- Left Time	.51
Wedge Index -------- Right Hand	.61
Wedge Index --------- Left Hand	.61
Shock Index ---- (T-P) - Right	.72
Shock Index ---- (T-P) - Left	.73

---

[11] Wherry, Robert J., Construction of a Test Battery for Persistence. (University of North Carolina, Project No. 5.). Washington, D. C.: N.R.C. Committee on Selection and Training of Aircraft Pilots, 1941. (Included as *Supplement* I to the present report.)

[12] Thurstone, L. L., The Vectors of Mind. Chicago: University of Chicago Press, 1935.

Presented in Table VII are the intercorrelations (Pearsonian) of the ten variables for the 129 men for whom complete records were available in the 1941 study.

TABLE VII

Intercorrelations Among the Ten Measures (Correlational Matrix)

	Chest Ergometer		Hand Dynamometer				Wedge Test		Shocker	
			Right		Left				(T-P)	(T-P)
	Pull	Time	Grip	Time	Grip	Time	Right	Left	Right	Left
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(12)	(19)
(1)	----	-.050	.471	-.107	.407	-.083	-.134	-.033	.126	.107
(2)		------	-.011	-.066	.012	-.134	.058	.157	.054	.001
(3)			------	-.173	.794*	-.136	-.110	.074	.074	.119
(4)				------	-.053	.513*	-.039	-.045	.012	.022
(5)					------	-.243	-.078	.047	.104	.126
(6)						------	-.015	.015	.047	.003
(7)							------	.612*	.025	-.094
(8)								-----	.136	.099
(12)									----	.726*
(19)										-----

*Right-left correlations (reliabilities).

The original factor loadings were rotated three times to achieve meaningfulness. The loadings after the third rotation are presented in Table VIII below.

TABLE VIII

Factor Loadings (Third Rotation) for Ten Selected Measures of Pain and Fatigue

		I	II	III	IV	h^2
(1)	Chest Ergometer ------- Pull	-.066	.000	.496	-.326	.356
(2)	Chest Ergometer ------- Time	-.068	.039	-.096	-.209	.065
(3)	Dynamometer ---- Right Grip	-.029	.126	.345	-.263	.798
(4)	Dynamometer ---- Right Time	.028	.291	.036	.623	.474
(5)	Dynamometer------ Left Grip	-.067	.139	.829	-.226	.761
(6)	Dynamometer ----- Left Time	-.040	.285	.000	.662	.520
(7)	Wedge Index ---- Right Hand	.201	.502	-.285	-.277	.450
(8)	Wedge Index ----- Left Hand	-.332	.613	-.161	-.354	.636
(12)	Shock Index - (T-P) - Right	.497	.609	-.138	.000	.637
(13)	Shock Index - (T-P) - Left	.419	.608	-.126	-.113	.573

Factor I --- Apprehension. Factor III -- Momentary Strength.
Factor II -- Endurance of Pain. Factor IV --- Willingness to Exert Oneself.

The <u>first factor</u> having heavy loadings for the wedge and shock has been called 'Apprehension.' Considerable fear and apprehension were exhibited by the subjects in connection with these two tests, and more for the shock than for the wedge, probably due to the fact that they were blindfolded. Furthermore, the right hand was always the first tested with the shock and the first factor loading is heavier for this hand than for the left.

The <u>second factor</u> has been called 'Endurance of Pain' since large loadings on the pain measures are characteristic of this grouping. The <u>third factor</u> was called 'Momentary Strength' since it refers to the individual's maximum effort. The <u>fourth factor</u> seems to be 'Willingness to Exert Oneself' under strenuous physical conditions. It overlaps the strength factor as can be seen by the magnitude of the loading for chest-pull and grip.

These ten measures break down into two groups, one composed of the six measures of physical strength and endurance, represented by the factors of 'Momentary Strength' and 'Willingness to Exert Oneself,' and the other composed of the pain measures. This latter group is accounted for primarily by the first two factors, namely, 'Apprehension' and 'Endurance of Paint.' There is also evidence that the wedge is related to the fourth factor -- 'Willingness to Exert Oneself.' These Wedge indices are in part a function of the physical structure of the hand, and since the score on the wedge is the ratio of the 'point of pain' to the total penetration, the thicker the hand, the greater the possible penetration before extreme pain, with a correspondingly larger ratio. This fact possibly accounts for the magnitude of the loading of this measure with respect to the fourth factor. It should be noted that there is evidence of a fifth factor running through the measure of time for the chest ergometer.

In his study, Wherry used a battery of fourteen measures, including four measures of persistence at physically tiring tasks, and six measures of persistence in painful situations. These data yielded four factors interpreted as: (1) endurance of pain, (2) strength, (3) willingness to exert oneself and (4) ergograph. His pain factor resulted from six measurements with the Howells wedge-test. The strength factor was related to height, weight, hand dynamometer and the finger dynamometer. The third factor was also related to the two dynamometers and to supporting an extended weight. His fourth factor was unique.

These two independent studies using measures of strength, endurance, and pain, which although similar, were scored differently, reveal an astonishing amount of agreement as to the grouping of the loadings for the various sets of measures. While this agreement may be entirely fortuitous, it is nevertheless more encouraging for carrying on future work than if the groupings had been entirely at variance. Furthermore, both sets of loadings seem to have 'face validity.'

CONCLUSIONS

The various measures of pain and fatigue studied in this investigation appear to be fairly reliable. Increased refinement and standardization would probably increase this reliability.

The evidence indicates that the constant stimulus shocker and the hand dynamometer have sufficient reliability to warrant being given a field trial for predicting resistance to pain and fatigue. The shocker used in these experiments has a reliability of .91 for the average of the terminal scores based on two trials with each hand. The measure of fatigue recommended here is the Rochester modified hand dynamometer, which has a test-retest reliability of .60 for the sum of two trials with the preferred hand.

The measures of pain appear to be independent of the measures of fatigue.

The pain tests can be accounted for by two factors, apprehension and endurance; the fatigue tests by two other factors, momentary strength and willingness to exert oneself. These results confirm Wherry's analysis of another, albeit, similar battery of pain and fatigue tests.

For present testing purposes, the wedge penetration test and the chest ergometer may be discarded.

RECOMMENDATIONS

Observation of the subjects while taking the tests indicates that the individuals approach the tests differently. Some submit passively to the test, some fight the pain and fatigue, many are apprehensive, while others treat the entire procedure calmly. It was the opinion of the staff at Rochester that perhaps valuable data might be secured from analyzing photographs of the individuals taking the tests.

Further data which might prove useful could be secured from physiological records before, during, and after the tests. Tension, perspiration, blood-pressure, psychogalvanic reflex, and heart beat are obvious functions to be considered.

It is recommended that in further studies in which the hand dynamometer is used two trials on the preferred hand be taken as the individual's ability to resist fatigue. This test is so exhausting that it is doubtful if the subject should be given more than two trials on any given day. If the shocker is used it would be advisable to give two trials with both the right and left hands, and take the average of them as the individual's ability to resist pain.

In using these tests, care must be taken to motivate the subject, and to impress on him the importance of making a favorable score.

After due consideration of the possibility of injury to the subject in administering the wedge test, and of the mechanical problems involved in the chest ergometer, it is recommended that these instruments be discarded for testing purposes. If the shocker and dynamometer, after field trial, show high enough validity to warrant using them as a battery, the wedge and ergometer may be introduced to increase the stability and reliability of the battery.

Validation of these tests must be carried out using not only passing and failing at one of our training stations as the criterion, but also success and failure as combat pilots overseas.[13]

It should be pointed out that tests of resistance to pain and endurance of fatigue are not necessarily limited to pilots, but concern themselves also with aerial gunners, commando training, and any other potentially dangerous, strenuous, or painful tasks.

---

[13] In Appendix B is found a description of a preliminary study of validation, involving athletes, physical education students, and 10 C.P.T. students.

APPENDIX A

DESCRIPTION OF THE TESTS DISCARDED IN THE PRELIMINARY PHASE

Five of the nine tests in the original battery were eliminated as a result of preliminary tryouts. A brief description of these tests along with the reasons for their elimination is given below.

(1) Application of radiant heat to the back of the hand.

This apparatus consisted basically of a 500-watt lamp and two Plano-Convex Lenses. The filament of the lamp was focused on the back of the hand through a small opening in a shield. The hand was kept in place by means of a spring clamp. A small shutter was manually operated in front of the opening in such a way that the rays contacted the hand for periods of three seconds with an interval of three seconds between exposure periods Since the threshold for heat sensation had recently been demonstrated to be fairly stable from individual to individual, the measure of resistance to the pain of the heat was the total time which elapsed between the first raising of the shutter and the eventual withdrawal of the hand from the apparatus. Each hand was tested in this manner.

This test procedure had to be discarded because it was found that the average subject adapted to the heat after about 18 seconds. If the hand was kept in the apparatus for this period of adaptation, no more sensations of pain from the heat were experienced. He would, thus, keep his hand in the apparatus until he suffered a severe burn. The test was obviously too dangerous to use.

(2) Immersion of the hand in ice-water.

The subject was required to place his hand in a bucket of water and hold it there as long as he could. The temperature of the water in this case was 32 degrees. The addition of salt to the water to lower its temperature was considered, but upon the advice of physicians this proposal was rejected. The measure taken was [illegible] the total time of immersion.

A similar condition prevailed for this test as in the case of the application of radiant heat. After a short time the receptors of the hand appeared to adapt to the cold water, with the result that the subject could keep his hand in the water for an indefinite period.* Hence, this so-called 'test' was not a test of the pain factor at all.

(3) Arm and leg fatigue tests.

In these tests the subject was required, in the one case, to maintain his arm perpendicular to his body; in the other, to maintain his leg perpendicular to the body while seated. The measure taken was the time during which an individual would voluntarily maintain his arm or his leg in this position. (An apparatus was devised originally which required the subject to hold out a weight proportional to the strength of his arm, but it was not constructed since it was felt that such a test might prove to be injurious.)

---

*Such adaptation has also appeared in other studies.

APPENDIX A (Continued)

These two fatigue tests were eliminated on the grounds of the length of time it took to administer them. It was found that subjects could maintain such positions for fifteen minutes or longer.

(4) The modified Mosso finger ergograph.

In this test the subject was required to maintain a weight proportional to his maximum pull for as long a time as possible. The index finger was attached to a pulley device carrying an adjustable load. After the maximum pull was determined for the subject, a weight of 75% of this maximum was attached to the pulley. The subject was instructed to keep this weight above a given point. A buzzer sounded when he was no longer able to keep the weight above this point. Measures of maximum pull and time maintained were recorded for each hand.

This test was discarded primarily because of mechanical faults. It was found to be extremely difficult to make a compact apparatus which could be readily adjusted to the various sizes of hands.

(5) The 'dry' shock.

The electric shock apparatus as first used had the current applied to the hand by means of a mesh of metal strips in a glove-like apparatus. The stimulus was a direct 'dry' shock from these strips. Four readings on points of first sensation and points of painful and very painful and the terminal point were taken. From these measures various indices were to be computed as ratios.

The 'dry' shock had to be discarded because it was found to reproduce slight local burns at the points of imperfect contact of the metal strips and the hand. A 'wet' shock in which two fingers of the same hand were immersed in a saturated salt solution was substituted in its place.

Other instruments capable of producing more drastic pain were suggested and considered, but these were discarded for both practical and humanitarian reasons.

APPENDIX E

VALIDITY STUDIES*

In a crude attempt to determine whether the tests had any validity, members of the Physical Education Department and the Athletic Coaching Staff at the University of Rochester were asked to rate the subjects in the experiment with whom they were familiar on their 'ability to take it.' Few individuals were rated by more than one person, and no one subject was rated by more than three. All ratings were made on a five-point scale.

Correlations were computed between these ratings on the 'ability to take it' and the various indices of pain and fatigue employed in the study. These correlations ranged from .08 to -.10.

In a further analysis, all members of the University of Rochester football squad who had participated in the experiments were separated from the other subjects on each of the measures. The hypothesis that the test results for the football squad were not significantly different from those of the general population was tested by chi-squared.** The probabilities fell between .40 and .90, indicating that the football men represented the general sample insofar as persistence and resistance to pain as measured by these tests are concerned.

Scores for 10 C.P.T. men who participated in the study were analyzed in the same fashion. They also did not differ significantly from the general sample.

---

*The obvious manner of validating these tests, together with the most promising ones from Wherry and Gilliland would be to see whether they actually distinguish between successful and unsuccessful combat pilots. (Reports of research conducted by A. R. Gilliland are to be published later in this series.)

** $\sum \frac{(f_o - f_t)^2}{f_t}$

APPENDIX C

COMPARISON OF THE MICROMETER WEDGE PRESSURE AND THE HOWELLS WEDGE PRESSURE

The Howells Wedge Pressure Test is the fore-runner of the micrometer wedge used in this study. Essentially it consists of lever and fulcrum with a twelve to one ratio. The wedge is placed in the subject's palm or other designated position and pressed down at a constant rate by allowing a stream of water with a fixed rate of flow, to flow into a container suspended on the lever. Because of the water, this apparatus is clumsy, large, and inconvenient to work with. The micrometer wedge has the advantage of compactness, cleanness, and is easily read. While the rate of increase in pressure with the micrometer may not be so constant as in the Howells apparatus, it appeared that the many advantages outweighed this single disadvantage.

In a preliminary study, both tests were administered to seventeen students. The point where the subject felt pain was recorded and also the terminal point. In the case of the micrometer, it was also necessary to record the initial point The symbols used in designating the various correlations are interpreted as follows:

I = initial reading (micrometer only)
P = Pain point
T = Terminal point
R = Right hand
L = Left hand
1 = measure secured from micrometer
2 = measure secured from Howells

Measures of Reliability:

Micrometer	Howells
$r_{R(1-T)\,L(1-T)} = .63 \pm .15$	$r_RT_LT = .85 \pm .07$
$r_{R(1-P)\,L\,(1-P)} = .67 \pm .14$	$r_RP_LP = .47 \pm .19$
$r_{R(\frac{p-t}{i-t})\,L(\frac{p-t}{i-t})} = .67 \pm .14$	$r_{R(\frac{t-p}{t})\,L(\frac{t-p}{t})} = .65 \pm .14$
$r_{R(P-T)\,L(P-T)} = .61 \pm .15$	$r_{R(T-P)\,L(T-P)} = .85 \pm .07$

The cross correlations between the various raw scores varied from .20 to .54. However, when the indices (T-P)/T for the Howells test were correlated with the indices (P-T)/(I-T) for the micrometer test for the left hand versus the left hand and the right hand versus the right hand, the correlations were respectively .66 and .56.

In view of the magnitude of the correlations and the advantages of the simpler apparatus, the micrometer wedge was used. Secondary evidence to support this use is found in the relative magnitude and agreement for the factor loadings found in this investigation and in that of Sherry.

APPENDIX D

[illegible] SHOCKER

John D. Coakley

This instrument delivers pulsating, unidirectional current of continuously variable magnitude within specified limits. Current from the secondary of the power transformer is passed through the subject by way of a 6J7G tube acting as a rectifier and current control tube. A combination of fixed and self-bias is used.

1. Output characteristics.

Due to the high plate resistance of the 6J7G tube connected as a pentode, the potential developed across the subject varies with the subject's resistance whereas the current is practically independent of this resistance and inversely related to the bias potential. The wave-form of the output is a portion of a sine-curve for small currents the duration of each pulse is of the order of 1 or 2 milliseconds and increases toward a limiting value of 8 ms. for maximal output. The instantaneous peak current may be varied continuously from the hum-level of the instrument (1 microampere or less) to 9.6 ma. Over this entire range approximately the current indicated on the calibrated dial will flow through the subject irrespective of the magnitude or of fluctuations in the subject's resistance provided this resistance does not exceed 50,000 ohms. If the resistance exceeds 50,000 ohms, the current will be somewhat less than indicated, especially in the upper part of the scale.

2. Controls

The functions of the controls are as follows:

S-1 Main power and filament key (See Fig. 1) S-1 also connects the battery into the circuit and accordingly must be left in the "off" position when the instrument is not in use.

S-2 Scale selector. The inner (minor) scale of the control dial applies when this switch is in the "up" position; and the outer (major) scale applies when the switch points downward.

S-3 Push-button for testing battery--See Section 4-d.

S-4 Key to power transformer. This switch must be "on" before any current can flow through the subject. It is advisable to set the current control at zero when changes in the position of S-4 are made. Failure to do so may introduce transients as described in Section 4-b.

S-5 Output selector. The current may be passed through a dummy load of 10,000 ohms by placing S-5 in the "up" position; or through the subject when S-5 is "down".

P-1 Pilot light

P-2 Current indicator. A neon bulb is placed in series with the subject (or dummy load) and indicates by its brilliance the magnitude of current flowing through the subject (or dummy). It is useful in assuring the operator that all connections to the subject are satisfactory and that the desired current is actually flowing. However, the test does not reveal the presence of short-circuits in the output leads.

Current Control. The calibration units are milliamperes instantaneous **peak** current.

Output Connection. The output is obtained from the outlet near the lower front corner of the right end of the instrument. Both leads are free from the chassis and also from the power lines.

Indicator Lights and Buzzer. These are located at the rear of the instrument and are turned on according to the following schedule:

	Major Scale	Minor Scale
Yellow	1.25 ma	0.35 ma
Green	2.60	0.56
White	3.80	0.70
Red	5.80	0.97
Blue	8.00	1.23
Buzzer	9.50	1.45

3. Operation.

The battery should be checked **just** prior to using the stimulator and at intervals during a long period of testing. Turn S-4 and S-5 off. Insert power plug and turn S-1 on. Allow **one minute** for the cathode of the tube to heat. Set the control to zero and connect the subject by pushing S-5 down. The desired current range is selected by S-2. Turn S-4 on and advance the current control from zero to the required level. When the test has been completed, return the control to zero and read the maximum current delivered by means of the floating pointer. All readings are made against the counter-clockwise edge of the pointer.

4. Protective Devices.

Inspection of Figure 2 reveals several devices for protecting the instrument and preventing undue stimulation of the subject.

A. Fuses in the power plug prevent fire or extensive damage to the instrument in case of circuit failure.

B. Transients due to fluctuations in the power lines are minimized by placing condensers across the primary and secondary of the transformer. These have capacities such that, even if the power line to the transformer is suddenly connected or disconnected, the peak of the resulting transient in the output is generally much smaller than the output peaks. Our observations indicate that the largest transients are of the order of 1 ma., when the output is 9.6 ma.

C. In addition to the "fixed" bias potential used to regulate the current, a self-biasing potential is developed across the cathode resistor, which determines the maximum current that will flow through the tube. This limitation ([illegible]) persists even in the case of complete battery failure or a defective potentiometer.

D. The meter enables the operator to check the potential of the battery at any time. When the battery test switch, S-3, is closed, the needle of the meter should deflect as far as the ink-line drawn across the meter-scale. Such a deflection requires considerably more current than is normally used by the instrument and accordingly the test assures the operator that the battery is fully adequate.

E. Fuses are interposed in the output line to prevent excessive current flow in case of circuit failure. These fuses will carry slightly less than ten ma. instantaneous peak and the combination will interrupt the circuit as the current approaches 20 ma. Generally both fuses must be replaced after overloading.

5. Maintenance and Repairs.

A. Replacement of Batteries

Remove the top cover and unsolder the two battery terminals. Remove the battery bracket and replace the battery. Resolder connections. Test the new battery as described in Section 4-d. If there is a negative deflection on the meter, the battery leads should be interchanged.

B. Replacement of Fuses.

Open fuses in the power plug may indicate short-circuits in the power cord, a defective transformer, or failure in the secondary circuit of the power transformer. The instrument should therefore be carefully checked before fuses are replaced.

Fuses in the output circuit are located near the outlet and may be reached by removing the bottom cover. If these are open, the circuit should also be checked Replacement fuses will be found in the container attached to the power transformer.

C. Other Repairs.

In case of circuit failures, the instrument may be submitted to persons of proper electronic skill or returned to the designer.

APPENDIX E

Instructions for Administration of:

1. Constant Stimulus Shocker
2. Hand Dynamometer
3. Chest Ergometer
4. Wedge Pressure Test

CONSTANT STIMULUS SHOCKER

Method of Operation

1. The battery should be checked just prior to using the stimulator.

   Press S_3 and read meter. It should register.

2. Turn S_4 down and S_5 up (off). S_5 up = load

3. Insert plug into wall socket, S_5 down = subject

   turn S_1 up (on), and <u>allow one minute for warm up</u>. (P_1 should light when S_1 is turned up.)

4. Set dial control to zero.

5. Turn S_4 up and with S_5 up, P_2 should glow as dial control is turned on.

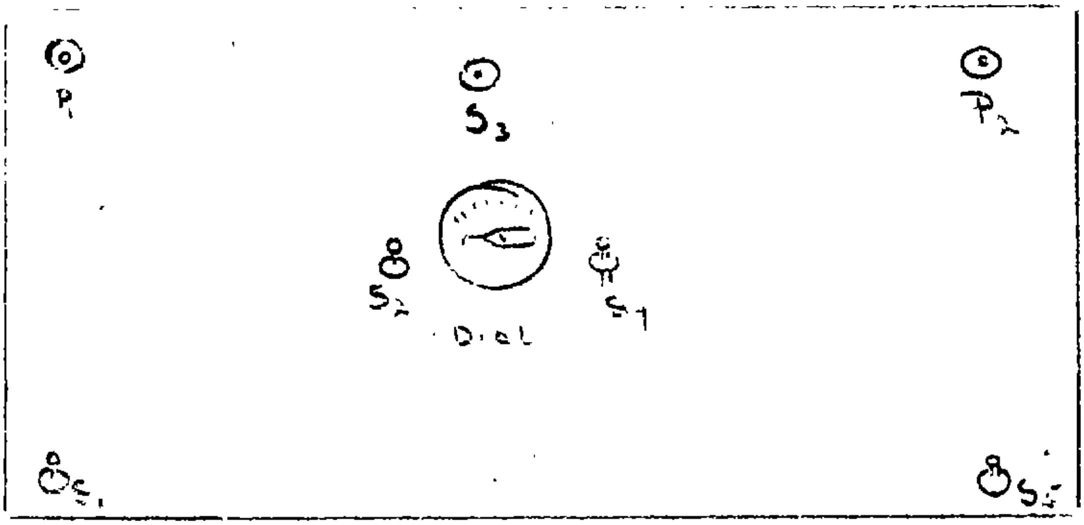
   Return dial control to zero.

6. Push S_5 down. Select current range from S_2: up = minor, down = major.

7. With S_4 up, turn S_5 down.

The apparatus is now ready for testing. See accompanying instruction sheet for procedure.

8. Read the dial on the counter-clockwise edge of the rider.



CONSTANT STIMULUS SHOCKER

Instructions for Administration

(Instruments: shocker, 2 electrodes, 2 100-c.c. beakers, saturated salt solution

Say: We wish to determine how much pain you can stand in terms of electric shock. You w place two fingers in the salt solution after which we will gradually increase the a of electric shock. When you first place your fingers in the solution, there will b no sensation of shock or pain since the current will be cut off. As the current is increased, you will be asked to answer a series of four questions regarding your se sations. This test will gradually increase in painfulness until you cannot bear it unless you have a lot of "guts." What we want to see is whether or not you can "ta it." Remember that, although the test will become very painful, it will not hurt you permanently. Now may I see your right hand.

(Examiner carefully examines the index and middle fingers for cuts or hangnails. If none is apparent, immerse the fingers in the salt solution. If cuts or hangnails are apparent, select two fingers free from these imperfections. Hav the assistant blindfold the subject.)

Say: I want you to tell me four things—first, when you feel any sensation at all; seco when the sensation becomes painful—by painful, I mean whatever you consider painf third, I want you to tell me where the sensation becomes very painful but where yo think you could stand some more if you had to; and fourth, you are to report where you can no longer take it. Then I will immediately cut off the current. Do not take your hand out of the solution until I tell you to do so. Now I am going to start the test.

(Examiner turns the rheostat control at the rate of one complete revolution every 60 seconds. He should have practiced this with a stop watch until he has an error of not more than 4 seconds.)

Say: Please tell me when you first feel sensation.

(No more comments should be made until the student reports sensation. If he reports sensation below 5 on the scale, stop the test. It means there is a minute cut on one of the fingers. Select another finger of the same hand and restart the test. When sensation is reported at a scale value of 5 or more, record this value.)

Say: Now I am going on and you report where it is painful.

(No comments until the student reports pain. Then record dial reading.)

Say:; Now we are going on until you report the sensation is very painful but you think you can stand some more.

(No comments until the student reports very painful. Record dial reading.)

Say: Now we are going on until you cannot stand it any longer. Let us see if you can ta it.

(No comments. As soon as subject says stop, cut the current by reversing the rheostat. After 10 minute interval or more, test the other hand.)

WEDGE PRESSURE TEST

Instructions for Administration

Say: The purpose of this test is to find out how much pressure you can stand on the palm of your hand. We are going to find this out by screwing this wedge into the palm of your hand. Now will you please put your hand palm up here in the apparatus.

(Operator adjusts the wedge and the subject's hand so that the wedge falls about the center of the palm. The axis of the wedge is parallel to the finger bones.)

Say: First, I will adjust the wedge so that it exerts the proper initial pressure on your hand. This will not hurt.

(Operator turns the wedge screw until the ratchet spring gives, and records the reading at this point.)

Say: Now I want you to tell me two things as the wedge presses on your hand. I want you to tell me when the wedge begins to be painful. That is, tell me when it begins to hurt, but you feel that you can still stand more pressure. Next, I want you to tell me when you have had all the pressure that you can stand. When it is as painful as you can stand, say stop, and the pressure will be released immediately.

(Operator begins to turn wedge screw slowly.)

Say: First, tell me when you feel that it is painful.

(After pain is reported, the reading is recorded.)

Say: Now tell me when you want to stop.

(Operator records terminal reading.)

Supplement I

Preliminary Report on Construction of a Test Battery for Persistence

by

Robert J. Wherry

with the assistance of

R. C. Rogers
E. R. Danzig
C. Wherry

A progress report on research conducted at the University of North Carolina, Chapel Hill, North Carolina, by means of a grant-in-aid from the National Research Council Committee on Selection and Training of Aircraft Pilots from funds provided by the Civil Aeronautics Administration.

Construction of a Test Battery for Persistence

I. Background.

A study by T. H. Howells[1] was taken as the basis for the present study. While he had no correlations with success in flying, he did present intercorrelations for 11 tests. In order to select the tests to be used in the present experiment, factor analysis of Howells' table of intercorrelations was performed with the results indicated in Table I.

Table I. Factor Analysis of Howells' Tests.

	Withstanding Discomfort	Withstanding Shock	Palm Sensitivity
Hand Dynamometer (1/2 pull)	.60	.21	.18
Needle sticking palm	.20	.12	.38
Burning of palm	.41	.27	.06
Electric Shock (R Hand)	.56	.58	.00
Electric Shock (L Hand)	.55	.64	.07
Peg Pressure, R palm	.82	.06	.20
Peg " , R wrist	.79	.12	-.05
Bar " , R thumb	.81	.10	-.11
Peg " , L palm	.79	.02	.37
Peg " , L wrist	.80	.18	-.07
Bar " , L thumb	.82	.04	-.11

II. The Test Battery.

Since the shock tests were a proposed part of the Gilliland battery[2] it was decided to base the tests on the first factor found above, using the six Howells pressure tests as a nucleus. His apparatus and method were duplicated as nearly as possible as described in his article. Since the hand dynamometer did not permit holding at any given stage, a spring-scale finger dynamometer was substituted in place of his first test. A test used by Ryan (holding a weight extended at arm's length to one side as long as possible) was also added. A laboratory Ergograph was also included in the battery, scored in terms of both time and distance pulled until fatigued.

In order to be sure that persistence rather than mere strength was being measured, weight, height, and hand-dynamometer squeeze were added to the battery.

---

[1] Howells, T. H. An experimental study of persistence. J. abnorm. (soc.) Psychol., 1933, 28, 14-29.

[2] Editor's Note. Reports of research conducted by A. R. Gilliland at Northwestern University, Evanston, Illinois, are to be published at a later date.

TABLE II - INTERCORRELATIONS OF ALL MEASURES

N = 31

	Height	Hand Dyn.	Ergograph		Finger Dynamometer		Extended Weight	Howells Wedge Pressure Test						Purdue Rating Scale		
		Grip	Dist.	Time	Pull	Time*		Palm Right	Wrist Right	Wrist Left	Palm Left	Thumb Left	Thumb Right	Skill	Judgment	Calmness
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1)**	.593	.533	.123	-.040	.531	.339	.343	.516	.326	.112	.313	.335	.318	.292	.059	-.054
(2)	----	.446	.179	.064	.348	.153	-.024	.403	.120	.010	.255	.145	.233	.143	.096	.121
(3)		----	.099	-.148	.689	-.082	.115	.305	.136	-.168	.144	.171	.125	.275	-.084	.000
(4)			----	.790	.170	-.009	.197	.089	-.026	-.176	.136	.263	.154	-.167	.111	-.200
(5)				----	-.105	.026	.010	.003	-.025	-.137	.125	.046	.054	-.219	.081	-.060
(6)					----	.053	.361	.352	.083	-.079	.223	.342	.255	.391	.115	-.087
(7)						----	.449	.685	.532	.685	.709	.550	.637	-.018	.203	.176
(8)							----	.318	.340	.434	.449	.583	.446	.098	.194	-.168
(9)								----	.748	.624	.859	.757	.829	.077	.429	.247
(10)									----	.635	.681	.717	.733	-.010	.322	.265
(11)										----	.767	.611	.718	-.044	.270	.285
(12)											----	.767	.854	-.063	.418	.318
(13)												----	.863	-.088	.355	.221
(14)													----	-.036	.470	.311
(15)														----	-.033	-.326
(16)															----	-.133
(17)																----

*Finger-dynamometer time was the length of time the subject maintained 50% of his maximum pull.

**Variable (1) was weight.

III. Subjects and Criteria.

This battery was administered to 31 C.P.T. elementary students, spring quarter, at Chapel Hill. The tests were given at or near the beginning of their training period.

At approximately the time of their last lesson a Kelly rating sheet[3] was filled in by each subject's instructor. This rating scale was scored for Skill, Judgment, and Tension[4]. These three scores were used as criteria for evaluating the usefulness of our persistence tests.

IV. Results.

The scores were coded for Hollerith equipment, and intercorrelations were run between the various tests and the three criteria. These intercorrelations are reported in Table II.

A factor analysis of the tests and criteria yielded 4 factors. Only one of the factors was not related significantly to at least one of the three criteria. The rotated factor loadings are given in Table III, on the following page.

---

[3] A Scale for Rating Pilot Competency. This scale, frequently referred to as the Purdue Rating Scale or the Kelly Rating Scale, was prepared by E. L. Kelly and is printed by the Purdue Research Foundation. See:

Kelly, E. L. Development of a Scale for Rating Pilot Competence. (Purdue Research Foundation, Project No. 2: Progress Report, September 1, 1940.) Washington, D. C. : National Research Council Committee on Selection and Training of Aircraft Pilots, 1940.

[4] The scoring was done according to a factor analysis similar to that described in:

Wherry, R. J. Analysis of Daily C.A.A. Log Books. (University of North Carolina Project No. 7.) Washington, D. C.: National Research Council Committee on Selection and Training of Aircraft Pilots. (Manuscript on file in Committee offices.)

Table III. Rotated Factor Loadings.

	Endurance of Pain	Strength	Willingness to Exert Self	Ergograph (?)
Weight	.21	.70	.36	.02
Height	.14	.72	.03	.22
Hand Dyn. (Squeeze)	-.08	.67	.43	-.10
Fing. Dyn. (Pull)	-.02	.50	.68	-.03
Fing. Dyn. @ 1/2 (Time)	.76	.14	-.02	.08
Ergograph (Time)	-.06	-.01	.30	.90
Ergograph (Distance)	-.02	-.06	-.04	.85
Extended Weight	.37	.00	.49	.07
Howells Palm R	.82	.43	.22	.04
" Wrist L	.76	.09	.22	-.05
" Wrist R	.82	-.23	.14	-.04
" Palm L	.90	.16	.20	.18
" Thumb R	.77	-.01	.49	.12
" Thumb L	.87	.06	.36	.09
Kelly RS-Skill	-.17	.33	.31	-.28
" -Judgment	.34	-.15	.31	.12
" -Calmness	.37	.09	-.35	-.06

V. Conclusions.

1. Strength (height, weight, hand-dynamometer squeeze and finger-dynamometer pull) is positively correlated with estimates of flying skill. Measures of this factor are unrelated to performance on endurance tests. This factor is not related to estimates of Judgment or Freedom from Tension.

2. The Howells tests are all highly intercorrelated with one another and with time the finger dynamometer was held at 1/2 maximum pull, and yielded a factor which was named Endurance of Pain. This factor was unrelated to Skill estimates, but did correlate positively with both estimates of Judgment and estimates of Calmness.

3. A third factor - tentatively named Willingness to Exert Oneself - had high loadings on finger and hand dynamometer, the extended weight test, and the two thumb tests. This factor had a positive loading on Skill and Judgment estimates and a negative loading on Calmness estimates.

4. A fourth factor was specific to the two ergographic measures and was unrelated to any of the estimates of flying success.

VI. Next Steps.

This study is to be repeated on another sample. Certain tests are to be dropped and others added for tryout. This study will be ready to report after the students complete the training course and rating sheets are available for criteria.

It is hoped that the results from this study may be combined with findings by Gilliland and Dunlap to furnish a real start toward future research on the problem of Endurance.