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A Factor Analysis of Tests Designed to Measure Persistence

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A FACTOR ANALYSIS OF TESTS DESIGNED TO MEASURE PERSISTENCE*

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THE PROBLEM

Statement of the need. It has been generally assumed that persistence is an important factor in determining the success or failure of an individual.

In school work there is a good reason to believe that persistence, or sticking to a task, is one of the main factors that helps to supplement or compensate for ability. . . .

Persistence is also a prime factor of success in the workaday world. The rolling stone has won proverbial fame for failure. Studies of successful men, whether in business or in professional life, indicate that in every case there is a certain persistence of activity that produces the fruits (22, 321-2).

The study of this factor, however, has not been simple. G. W. Allport (1, 418), in reviewing briefly the approaches to this aspect of personality, observes:

The belabored concept of involuntary perseveration was the psychologist's timid, half-hearted gesture toward a troublesome but inescapable problem in personality. The concept of persistence is far bolder, and in the long run should prove sounder. If so, it will take care, partially at least, of the thorny problems of "will power" whose inclusion in any psychological schedule of personality is as necessary as it is vexatious.

The attempts to measure persistence have been many; but the evidence concerning what these supposed tests of persistence actually measure is conspicuously meager. There is need for a study to determine what the tests measure. The present investigation attempts to meet this need.¹

* The author wishes to express his gratitude and acknowledge his indebtedness to Professor J. P. Guilford for helpful suggestions and criticisms throughout the course of the study, and to Jerry Thornton for assistance in the calculation of results and preparation of the manuscript.

¹ Porter and Henninger have made an unpublished study which constitutes a partial attack upon this problem. Their study is discussed briefly in the section on Interpretations and Conclusions.

Statement of problem. Stated specifically the problem of the present study is: What are the variables of behavior (factors) which are measured by the tests designed to measure persistence?²

This problem includes two sub-problems: (1) Is there a factor universal to the tests? (2) What other common factors are important in the tests? For each factor found, whether a universal or a group factor, the additional problems will be considered: (a) What is the nature of the factor? (b) Of what importance is it in determining the scores on the tests?³

Definition of persistence. Since the concept of persistence would necessarily determine, to a large extent, the selection of the tests to be included in the study, it was necessary at the outset to adopt a tentative formulation of what is meant by persistence. The interpretation given to the concept may be expressed as follows: To persist is to continue trying to accomplish a task in spite of difficulties, to cling to a purpose in spite of counter influences, opposition, or discouragement. This is in essence what is common to the two terms *perseverance* and *persistence* as defined in *Webster's Collegiate Dictionary* (3d edition). It is also in fundamental agreement with one of the definitions of persistence given in the *Dictionary of Psychology*: persistence is "continuance of a line of behavior against opposing incentives or motives" (28, 197). This formulation is obviously tentative, and was adopted only for purposes of definition of the field to be investigated.

The above definition of persistence does not appear to include

² There is need in psychology today for more adequate determination of the dimensions of personality. It is hoped that this study will contribute to the broader program which aims at the ultimate establishment of a set of dimensions which will make possible an adequate scientific description of personality. This does not imply (as some have assumed) that a single mold will be found into which every individual may be fitted. It means rather the discovery of those dimensions of the individual which must be measured in order to understand him most adequately in comparison with others—much as it is now known that in order to describe certain aspects of a box one must measure its length, width, and depth.

³ To gain information concerning the above problem, intercorrelations were found between various tests of persistence and several other measures. These intercorrelations are of interest in their own right. They are presented in Table III in the section on results.

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the concept of perseveration (the "p" factor).⁴ In fact, there is little *a priori* reason for assuming a relationship between the two concepts. As Allport (1, 417-8) has pointed out, the tests employed in determining "p" involve for the most part only simple sensory or motor performances, and "They are too trivial to tap the developed volitional functions of personality." Should both persistence and perseveration become established as scalable dimensions of personality, it will be an important problem to determine empirically the relationship between the two dimensions. The present study, however, is not concerned with this problem, and will be limited to an investigation of tests which appear to fall under the concept of persistence as defined in the preceding paragraph.

PLAN OF THE PRESENT STUDY

The general plan of the present study has been to administer a battery of representative tests of persistence to a large group of subjects, to find the intercorrelations between the scores, and to analyze these interrelationships by means of factor analysis.

Reasons for using factor analysis. Factor analysis was adopted because it seems to offer the greatest promise of (1) revealing whatever factors may be common to the tests, (2) indicating the weighting of these factors in the individual tests, and (3) permitting at least partial identification of these factors.⁵ Factor analysis, however, is not the only approach possible. The experimental results obtained might be interpreted by means of logical analysis of the table of simple intercorrelations (perhaps aided by the calculation of partial and multiple correlations). Those persons who are skeptical of factor analysis may wish to attempt such an interpretation. In the opinion of the writer, the conclusions arrived at would not differ greatly

⁴For a summary of the evidence which forms the basis for the concept of the "p" factor, see C. Spearman, *The Abilities of Man*, 1927, pp. 291-307. For a brief but good critical review of the concept and the experimental studies which led to its formulation, see Allport (1), pp. 416-418.

⁵When these facts are known, the groundwork is laid for the construction of usable batteries to measure the desired variables.

from those which have been reached by the factor-analytic approach. Evidence supporting this opinion will be presented in the section on results.

In some cases, however, the simple intercorrelations might not be adequate to reveal real relationships which might be revealed by factor analysis. It is possible for the scores on two tests to be determined by the same factors and yet for the correlation between the tests to be zero. This may be illustrated by a hypothetical case. Suppose that tests I and II have in common two factors, A and B, with respective weightings of .6 and .4, and .4 and $-.6$. The correlation between the tests would be: $(.6 \times .4)$ plus $(.4 \times -.6)$, or zero.⁶ Thus from the simple intercorrelations it would be impossible to know that tests I and II had anything in common. If, however, both tests were correlated with other tests, some of which were weighted with factor A and others of which were weighted with factor B, factor analysis of the matrix of intercorrelations would disclose the presence of the common factors in tests I and II.

Tests included in the series. In choosing the tests to be included in this experiment, the experimenter attempted to select tests which might be expected to have in common a factor of persistence but which would not have other factors common to all of them.⁷ In other words he attempted to select tests adapted to the factor-analytic approach. To this end the tests were chosen with regard to the following criteria: (1) the tests should be such that the score in each case would be determined, in part at least, by the degree of persistence exercised by the subject; (2) the tests should represent fairly the more promising tests of persistence used by previous investigators; (3) no single ability factor should be common to all of the tests (*e.g.*, the tests should not all involve verbal ability); (4) no single interest factor should be common to all the tests. An additional practical consideration

⁶ "The correlation between two tests is equal to the cross-products of the factor loadings in the corresponding abilities held in common by the two tests" (13, 475).

⁷ It is not assumed that the tests are pure tests of persistence. Factors other than persistence enter into most, if not all, of the current tests which purport to measure persistence.

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was: (5) the time required for administration of each test should not be excessive.

The following is a brief description of the tests chosen on the above bases.

(1) *A Shock Test.* This was patterned closely after Howells' shock test.⁸ Two trials each were given first to the right hand and then to the left hand. The electrodes were clamped to the ventral surfaces of the thumb and middle finger of the same hand. The current was a direct pulsating current, obtained from an apparatus built according to Howells' specifications (16).⁹ A milliammeter in the circuit indicated the actual flow of current through the subject's (S's) hand. The intensity of the current began at zero and was increased at the rate of one-tenth milliampere per second until the S said "stop." One preliminary trial was given to allay the S's early misgivings; in this trial the current was increased from zero to .3 milliampere, an intensity just sufficient to insure that all Ss would get a tingling sensation in the fingers. The score for each of the four succeeding trials was the time the S continued to take the current before he said "stop."¹⁰ Time was measured by counting the ticks of a metronome which beat once per second.

(2) *Pressure Tests.* These were patterned closely after Howells' pressure tests. S was given six trials in each of which a wooden instrument was pressed into his flesh with the pressure increasing at a constant rate until he said "stop."¹¹ The score on each trial was the time in seconds that S endured the pressure.

⁸ This test resembles that of Faddeev (8) also. Howells originated a battery of tests intended "to obtain a measure of differences between individuals in persisting, in spite of increasing discomfort and distress, in the endeavor to accomplish a task or achieve an objective" (17, 14). The shock, pressure and maintained handgrip tests, which are included in the present study, constitute most of Howells' battery.

⁹ The author is indebted to Dr. W. E. Walton and to Associate Professor F. W. Norris for helpful suggestions in the duplicating of Howells' apparatus for the shock and pressure tests.

¹⁰ An arbitrary limit for each trial was set at 50 seconds. Fifteen Ss reached this limit in one or more trials.

¹¹ The pressure increased at approximately 493 grams per second. Eight Ss continued for a minute on one or more trials; in each case the trial was ended by the experimenter to prevent possibly injury.

At least one and one-half minutes intervened between trials. Time was measured by stop-watches.

The six trials consisted of three tests, each administered to the right and left hands. In trials 1 and 2 a rounded wooden peg was pressed into the center of the palm. In the third and fourth trials the same peg was pressed into the back of the wrist at a point between the ulna and radius about 3 cm. above the wrist bones. In the fifth and sixth trials a wooden instrument with an edge 8 cm. long and 2 mm. wide was pressed down upon the back of the first phalanx of the thumb.¹²

(3) *Handgrip*. Preliminary to test 4 below, we obtained a measure of S's handgrip.¹³ Each S was given a total of ten trials, five with each hand. The trials, given at twenty second intervals, were alternated between the right and left hands.

(4) *Maintained Handgrip*. The score on this test was the time that S held the pointer of the dynamometer above a marker set at a certain point on the dial. The difficulty of the task was made approximately equal for all Ss by placing the marker at a point determined on the basis of S's strength of grip. This point was, in each case, two-thirds of the median strength of grip for that hand as determined in test 3 above. S was seated during the test and rested his arm on a table while holding the dynamometer face up. Four trials were given, alternating between right and left hands, with two minutes rest after each trial. Time was measured by means of stop-watches.

This test was similar to one used by Howells, in which S held the pointer above a red line placed at one-half his strength of grip. Howells apparently gave only one trial with one hand, and he does not state how the strength of grip was determined. In the present experiment it was hoped that by use of four trials and an adequate determination of strength of grip, a more accurate measurement of whatever is measured by the test might be obtained. In setting the difficulty of the task for each S at two-thirds his strength of grip, the procedure used followed that of

¹² For further description of the apparatus, see Howells (17), pp. 18-19.

¹³ The improved form of the Smedley dynamometer was used. At the beginning of the experiment this instrument was supplied with a new spring and was calibrated accurately in kilograms by the manufacturers.

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Fessard *et al.* (10). These authors state that any value down to one-half the maximum strength is fairly satisfactory, but below that value fatigue is too slow in developing (11).

While the present test was patterned more directly after the above mentioned tests, it is to be noted that the general nature of the test is quite similar to that of Fernald's volometer test (9), Bronner's dumb-bell test (3, 68-70), and Studman's tapping test (21). In each of these tests the task requires the S to continue muscular effort in spite of fatigue.

(5) *Holding the Breath.* The score on this test was the time the S held his breath. S began with a deep breath. His nose was clamped shut so that he was forced to breathe through his mouth; and the time was taken, by means of a stop-watch, from the moment he closed his mouth until he opened his mouth again. Four trials were given, with a rest of two minutes after trials 1 and 3 and a longer rest period after trial 2.

This test was devised by the present experimenter. It was included in the series because (1) the task set for S is a simple one which anyone can perform, (2) the task is different from others included in the study and may involve interests and abilities somewhat different from those involved in other tests, (3) the score appears to be readily affected by the degree of persistence exercised by S.

The time one holds his breath will, of course, be determined in part by factors other than persistence.¹⁴ Important among these other factors are lung capacity, basal metabolic rate, efficiency of heart and circulatory system, emotional excitement (as in embarrassment, *e.g.*), depth of breath obtained, and affections of the respiratory system such as in colds and asthma. No attempt was made to correct for these other factors. The primary interest was to discover what factors this test has in common with the other tests used in the study; and it was feared that attempted corrections might serve only to obscure the true relationships.

(6) *Motor Inhibition.* This test was adapted from the test of motor inhibition in the Downey Group Will-Temperament

¹⁴ A similar objection may be raised against most, if not all, the tests purporting to measure persistence.

Test, in which the task is to see how slowly one can trace a line. The procedure was almost identical with that used by Downey except that (1) the test was administered individually, and (2) the second and third trials were both two and one-half minutes in duration. Thus three trials were given, the first a thirty second practice trial, followed by two two and one-half minute trials, the trials being separated only by the time required for giving instructions. The score on the test was the number of segments of the line traced in the second and third trial, the high scores indicating lack of motor inhibition.

This test was included because it seems related to the tests of maintained handgrip and holding the breath; it was hoped the results might be of value in interpreting the scores on these latter tests. Also, the definition which Uhrbrock (26, 40) gives for motor inhibition, "after numerous consultations with Dr. Downey," suggests a relationship to persistence: "the power to hold back a motor discharge; to keep an impulse under control; to achieve a purpose slowly." This definition suggests that what is measured in the test is persistence in the inhibitory activity.

(7) *Aiming Test*. This was an attempted adaptation of Downey's test of "volitional perseveration." The S was told that he would be tested on just one trial of the aiming test, which consists of striking with a pencil at ten crosses on a target. He was, however, permitted "some time to practice first." The score on the test was the time, measured by a stop-watch, that S continued to practice before indicating that he was ready to take the trial that would count.

Downey's task of practicing disguising one's handwriting was rejected because in some cases the results of the Downey test are vitiated by previous practice. The aiming test seemed a good substitute because it is a task in which S is not likely to have had previous practice, and because it offers opportunity for an indefinite amount of practice.

Observation of the behavior of Ss as they took this test, however, raised a question as to whether the test was eliciting the sort of response that had been expected. Some Ss seemed to take the practice period merely as an opportunity "to get the hang

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of" the task. Several Ss made remarks which indicated that they felt practice did not improve their scores. Perhaps different instructions or a different task would yield better results. Of course, it is to be remembered that the reports on Downey's test of volitional perseveration have given little reason for one to expect good results from it (26, 31-32, 59; 22, 343; 23, 301). Howells (17), however, has reported a correlation, for seventeen Ss, of .81 between his battery and Downey's test of volitional perseveration. This was considered sufficient reason for including a modification of the test in this study.

(8) *Perceptual Ability Test*. This test was a modification of the "Stories Test" of Hartshorne and May, which was developed for use with college students. The test consisted of a story, written for the purpose, which was presented in typed form.¹⁶ The material was easy to read at first, but as S progressed in the story the reading became increasingly difficult because of an increasing number of changes in the spacings of letters and increasingly radical alterations in the punctuation and capitalization. Finally, the material ceased to make sense, and so it became impossible to decipher it. S's task was to see how far he could figure out the correct reading.

The Ss were told the material would all make sense if properly spaced and punctuated. So far as the experimenter (E) could judge, no one of the 63 Ss who reached the impossible part of the story suspected that it did not make sense.

Three scores were obtained from this test: (1) the amount of material S deciphered correctly; (2) the time taken to complete the first three paragraphs; (3) the time S continued to work at the task. An arbitrary limit of thirty minutes was set for this task, and the seventeen Ss who continued this long were stopped by E. Ss were not told that there was a time limit, however. They were told that their only score was determined by the distance they were able to read correctly, and were given the impression that time did not count.

(9) *Word Building Test*. This test was patterned closely after Chapman's word building test. S was given the six letters,

¹⁶ A copy of the story is found in the appendix.

BRTAOU, and was asked to make as many words as he could from various combinations of these letters, using two or more at a time. Three scores were obtained: (1) a score based on the number of words constructed; (2) the time it took S to get his first ten words; (3) the time S continued to work at the task. An arbitrary limit of thirty minutes was set for this task, and the five Ss who continued this long were stopped by E; but the Ss were not told of the time limit. They were instructed that the score would be the number of words they wrote.

The score based on the number of words constructed was obtained in the following manner: By means of a recognition test, described below, it was discovered that of the 55 words which could be built according to the rules, 26 were recognized as words by more than 90 per cent of the Ss in the experiment.¹⁶ The score given each S was the number of these 26 commonly known words which he included in his list. Only these 26 commonly known words were counted in order to eliminate in part the effect of differences in ability upon the score.

(10) *Verbal Recognition Test.* A check list containing the 55 words which could be built in the word building test, with 25 nonsense syllables composed of the same letters and scattered among them, was presented to S who was instructed to put an X in front of the words and a zero in front of the combinations which were not words.

The chief purpose of giving this test was to obtain information which could make possible a correction for differences in ability in the word building test. The time S took to mark the check list, however, was recorded.¹⁷ This score was included in the study in the hope that it might yield some evidence concerning the tendency of Ss to work swiftly or slowly.

The above ten tests were administered to each S individually. The following five tests were given to the Ss in groups. These latter tests were included in the beginning course in psychology as

¹⁶ Sixteen words were recognized by all of the 189 Ss. The remaining words were not recognized by the indicated number of Ss: auto, 5; boar, 4; bout, 9; car, 1; oat, 1; or, 3; rot, 4; tab, 9; tour, 5; tuba, 15.

¹⁷ This time included all checking S did before returning the test blank. Some Ss checked their work; others did not.

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demonstrations of psychological techniques. Ss were informed that the results would be used for experimental purposes, but they were not told that the tests had any connection with the test series which they took individually.

(11) *Wang Test (27)*. This was a questionnaire composed of fifty of the most diagnostic items from Wang's questionnaire. Wang had begun with a large group of items which had been considered by a group of judges to be diagnostic of persistence. From these Wang had selected the 111 best items on the basis of tests for internal consistency. His criterion groups were the upper 10 per cent and the lower 10 per cent of his 512 Ss. In an appendix Wang gives the number of *yes* and *no* responses to each item for each criterion group. Using Wang's figures, E determined the degree to which each item was diagnostic of the criterion groups by finding the ratio of the answers in the diagnostic direction to the answers in the opposite direction. Fifty items were found to have ratios of three or more. Of these fifty items two were almost exact repetitions of others included in the fifty. These two were omitted, and for them were substituted the following two questions from Wang's list: "In an argument, do you find it difficult to give in?" "Are you willing to sacrifice comforts for future gains?" These two questions had, respectively, ratios of 2.8 and 2.7.

Ss answered each item by encircling *yes*, *?*, or *no*. The score on the test was taken as the number of items answered in the manner considered by Wang as diagnostic of persistence, plus one-half the number of items omitted or answered with *?*.¹⁸

(12) *Rating Scale for Persistence*. This was a graphic scale with descriptive phrases, constructed by E, by means of which S rated himself. A copy of the scale and the directions given appear in the appendix. The administration of the scale was preceded by a demonstration by E of how to use a self-rating scale. In this preliminary demonstration E emphasized that a rater should strive to find the exact point on the scale that best describes him. The Ss were also cautioned to consider only the one trait in question.

¹⁸ Wang is not explicit concerning his scoring of uncertain answers.

(13) *Rating Scale for Self-Confidence*. This was another graphic scale constructed by E and used to obtain self-ratings. It was administered immediately following the scale for persistence. A copy of the scale with directions is found in the appendix.

(14) *Ascendance-Submission Test*. The Allport A-S Reaction Study was administered to all Ss, using the different forms for men and women. For this experiment those items which were contained in both forms were selected and scored according to the scoring values for men published by the Allports (2). There were eighteen such items out of a total of 49 items in the form for women and 41 items in the form for men. The score on the A-S test in this study, then, is the score on these eighteen items.

(15) *Verbal Ability Score*. Since some of the tests involved verbal material, some measure of verbal ability was needed in order to discover the importance of this ability in determining the scores. The measure adopted was based on three sub-tests in Form 5 (the Wells revision) of the Alpha Examination. The score was the sum of X_3 plus $2X_4$ plus $2X_5$, where X is S's score on the sub-test, and where the subscripts 3, 4, and 5 refer to the respective sub-tests of the Alpha Examination. These sub-tests all involve tasks which require verbal ability. They are, respectively, the best answers test, same-opposite vocabulary test, and mixed-up sentences test.

The formula used for the verbal ability score was developed by J. P. Guilford.¹⁰ On the basis of factor analysis of 108 samples, Guilford found that verbal ability was important in four sub-tests of Form 7 of the Army Alpha Examination. The three sub-tests used from the Wells revision are very similar in form to the corresponding parts of the original Alpha Examination; hence, the formula developed on the basis of Form 7 was considered satisfactory.

Besides the scores on the above tests the following data were obtained for each S: height, weight, sex.

Summary of data used in this experiment. Following is a resumé of the scores and other measures which were gathered in

¹⁰ Guilford, J. P. A new revision of the Army Alpha Examination and a weighted scoring for three primary factors, *J. appl. Psychol.*, 1938, 22, 239-246.

this experiment and the analysis of which will be reported in this study.

From the performance tests were obtained ten scores which there is some reason to believe are measures of persistence:

- (1) total time in four trials of holding the breath
- (2) time spent in practicing the aiming test
- (3) distance traced in two trials of motor inhibition test
- (4) time spent on perceptual ability test
- (5) amount of material read in perceptual ability test
- (6) time spent on word building test
- (7) number of familiar words written in the word building test
- (8) total time on four trials of shock test
- (9) total time on six trials of pressure tests
- (10) total time on four trials of maintained handgrip

These ten scores represent quite adequately the better performance tests for persistence proposed by previous experimenters. Two exceptions are notable: (1) No number building test (5) was included; the word building test, however, is similar. (2) No puzzle tests were included. These latter were omitted principally because of the excessive time required for such tests, although other objections could be raised against them also.

Two paper and pencil tests were intended to measure persistence:

- (11) Wang test
- (12) self-rating on persistence

In order to help determine the influence of verbal ability upon the above scores, there was included a score for verbal ability:

- (13) total weighted score on sub-tests 3, 4, 5, of Revised Alpha Examination, Form 5.

To help identify the influence of physical factors upon the persistence scores, there were included:

- (14) total score for ten trials (both hands) of handgrip
- (15) sex
- (16) weight
- (17) height

The tendency or ability to work swiftly might have an influ-

ence upon the scores intended to measure persistence. To gain evidence concerning this possibility, there were included the following three measures:

- (18) time spent on verbal recognition test
- (19) time taken to read the first three easy paragraphs of the perceptual ability test
- (20) time required to construct the first ten words in the word building test²⁰

Finally, to discover possible relationships with measures of persistence and to aid in interpretation of relationships with items 11 and 12 above, there were included:

- (21) self-rating on self-confidence
- (22) score on eighteen items from the A-S test

Subjects. Ss for the experiment were 189 students from the beginning course in psychology. Of these 155 came from classes taught by E. The Ss included all of the members of the classes from which they came with the exception of eight individuals. Hence, the only important selective factors operating in the choice of Ss were those which determined registration in the classes.

The group of Ss included 135 men and 54 women. These Ss ranged in age from 17 to 37 years. Only eight Ss were above 26 years of age. One hundred fifty-nine Ss fell within the range of 18 to 22 years, inclusive.

Procedure. Five of the tests were given under group conditions. These were presented as a part of the regular class exercises, and the students were not informed that they had any connection with the experiment. Except for the rating scales these group tests were all taken on different days. The order of presentation was Army Alpha Examination, A-S test, Wang questionnaire, rating scales (persistence scale first). Students who were absent on days when a test was given took it later, usually individually. Before taking each of the tests, the students were told that the results would be used for research purposes and were urged to follow the directions carefully; before taking the

²⁰ The time scores in items 18, 19, and 20 were taken by means of a stop-watch but without stopping the watch; hence, the measurements were somewhat rough. The time taken for the first ten words had to be estimated for nine Ss, on the basis of the time recorded for more or less than ten words. Five Ss did not complete ten words.

questionnaires and rating scales, they were urged, in addition, to be as honest and as accurate as possible.

The remaining tests were administered under individual conditions. So far as possible the conditions were kept the same for all Ss. All were tested in the same room and by the same E; no other person was in the room, and no interruptions were permitted.

Each S came for a single two-hour session. At the beginning of the period preliminary instructions were given him, which were intended to orient and motivate him. The tests followed according to a definite schedule:²¹

- Two trials of holding the breath
- Aiming test
- Two trials of holding the breath
- Motor inhibition test
- Perceptual ability test
- Word building test
- Recess of a few minutes
- Verbal recognition test
- Handgrip test
- Three minute rest
- Maintained handgrip test
- Shock test
- Pressure tests
- Recording of height, weight, sex, age

The rest periods between trials of a test, as described in a previous section, and the intervals between tests as cited above were measured by a stop-watch and were kept as exactly as was possible without crowding the Ss unduly.

Throughout the experiment uniform instructions were given for each test. In the case of the general instructions at the beginning and the instructions for the perceptual ability, word building, and verbal recognition tests, typed instructions were presented to

²¹ Four persons were unable to complete the series in one session and were forced to return on a second day.

At the beginning of the experiment a tapping test similar to Studman's (21) was included in place of the handgrip tests. This was dropped because of difficulties with the apparatus, and the handgrip tests were substituted. Consequently, 29 Ss had to return on a second occasion to take the handgrip tests, four took both the tapping and the handgrip (handgrip first) in the original session, and three took the tapping and handgrip both in a second session. Those Ss who returned for a second session were motivated by being told that the scores would count as a part of the whole score for the previous session and that, to compensate for their coming a second time, the number of Ss who would be excused from a test would be increased to fifteen.

the S and were also read aloud by E. For the remaining tests the directions were given orally.

Through preliminary instructions an attempt was made to elicit a level of motivation which would be constant for all Ss and for all tests. To obtain the same degree of motivation for all Ss, each S was told that he would be tested for a number of physical and mental abilities, that the tests were such that he would have as good a chance as anyone to make good scores, and that the ten persons from his class who got the highest average for the series of tests would have their names posted and would be excused from one of the regular weekly quizzes. To obtain the same degree of motivation for all tests, E emphasized that the ten persons would be chosen on the basis of the *average* score for the whole series, and that, therefore, S should do his very best on *every* test.

It is too much to assume that by presenting a constant set of incentives to each S for the whole series of tests constant motivation was actually obtained for all Ss and for all tests. In so far as the technique used has failed to attain this end, the scores obtained must be considered to be in part a function of motivation.

ANALYSIS OF THE RESULTS

Method of computing correlations. The distributions of actual scores obtained by the 189 Ss for each of the tests in the series are given in Table I. The interest in this study, however, is not so much in the scores themselves as in the relationships between the scores. By analysis of the latter it is possible to uncover evidence concerning the factors which determine the scores.

The relationships were measured by means of Pearson coefficients of correlation. The coefficients were calculated by the machine method, the distributions having first been coded into from 11 to 27 steps. There was one exception; in the correlations involving sex it was not reasonable to calculate Pearson coefficients. The coefficients reported for sex are tetrachoric coefficients; in finding these Thurstone's tables were used.²² Biserial coefficients were also calculated for sex with all other

²² L. L. Thurstone *et al.* "Computing Diagrams for the Tetrachoric Correlation Coefficients," 1933.

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variables. These were quite comparable to the tetrachoric coefficients; one notable exception was the biserial correlation between sex and handgrip, which was found to be above unity.

In the case of eleven of the measures, as may be seen from an inspection of Table I, the distributions were seriously skewed.

TABLE I
DISTRIBUTION OF SCORES ON TWENTY-ONE VARIABLES

Holding Breath		Aiming		Motor Inhibition		Perceptual Time	
Step	f	Step	f	Step	f	Step	f
580-619	3	360-79	1	144-152	1	1800-99	17
540-579	1	340-59		135-143	1	1700-99	4
500-539	3	320-39	1	126-134		1600-99	3
460-499	4	300-19		117-125	1	1500-99	7
420-459	9	280-99		108-116		1400-99	2
380-419	5	260-79		99-107		1300-99	4
340-379	9	240-59		90-98		1200-99	7
300-339	12	220-39	2	81-89		1100-99	5
260-299	26	200-19	1	72-80	2	1000-99	7
220-259	38	180-99	4	63-71	1	900-99	13
180-219	31	160-79	4	54-62	1	800-99	10
140-179	38	140-59	5	45-53	6	700-99	12
100-139	7	120-39	12	36-44	11	600-99	22
60-99	3	100-19	11	27-35	35	500-99	22
		80-99	37	18-26	57	400-99	18
		60-79	50	9-17	53	300-99	17
		40-59	38	0-8	20	200-99	15
		20-39	23			100-99	4

Perceptual Amount		Word Building Time		Number of Words		Shock	
Step	f	Step	f	Step	f	Step	f
11	45	1800-99	5	26	1	200	8
10		1700-99	2	25	3	190-9	1
9	11	1600-99	3	24	9	180-9	1
8	16	1500-99	1	23	4	170-9	2
7	26	1400-99	5	22	10	160-9	1
6	18	1300-99	3	21	15	150-9	2
5	34	1200-99	4	20	8	140-9	2
4	13	1100-99	2	19	14	130-9	1
3	11	1000-99	16	18	10	120-9	3
2	11	900-99	15	17	24	110-9	7
1	4	800-99	17	16	15	100-9	11
		700-99	13	15	17	90-9	16
		600-99	19	14	16	80-9	20
		500-99	22	13	15	70-9	34
		400-99	34	12	10	60-9	28
		300-99	21	11	2	50-9	23
		200-99	6	10	6	40-9	20
		100-99	1	9	5	30-9	6
				8	3	20-9	3
				7	1		
				6			
				5	1		

TABLE I—Continued

Pressure		Maintained Grip		Wang		Rating on Persistence	
Step	f	Step	f	Step	f	Step	f
360	3	250-269	1	48-9	1	17	1
340-59		230-249		46-7	6	16	3
320-39		210-229	1	44-5	10	15	5
300-19		190-209	4	42-3	12	14	14
280-99	2	170-189	7	40-1	18	13	22
260-79	1	150-169	12	38-9	20	12	17
240-59	1	130-149	22	36-7	26	11	57
220-39	5	110-129	26	34-5	16	10	28
200-19	8	90-109	36	32-3	30	9	22
180-99	5	70-89	42	30-1	21	8	14
160-79	10	50-69	26	28-9	8	7	1
140-59	16	30-49	9	26-7	6	6	3
120-39	33	10-29	3	24-5	6	5	1
100-19	46			22-3	3	4	1
80-99	30			20-1	5	3	
60-79	21			18-9	1	2	
40-59	6					1	
20-39	2						
0-19							

Verbal Ability		Handgrip		Weight		Height	
Step	f	Step	f	Step	f	Step	f
140-4	1	680-719	2	99-101	1	186-7	3
135-9	4	640-679	7	96-98		184-5	6
130-4	3	600-639	13	93-95	1	182-3	7
125-9	5	560-599	17	90-92		180-1	15
120-4	12	520-559	31	87-89		178-9	19
115-9	15	480-519	37	84-86	6	176-7	14
110-4	16	440-479	20	81-83	2	174-5	23
105-9	17	400-439	9	78-80	14	172-3	18
100-4	19	360-399	11	75-77	7	170-1	18
95-9	17	320-259	13	72-74	15	168-9	15
90-4	20	280-319	22	69-71	23	166-7	8
85-9	20	240-279	5	66-68	25	164-5	14
80-4	10	200-239	2	63-65	21	162-3	3
75-9	4			60-62	18	160-1	9
70-4	8			57-59	17	158-9	5
65-9	10			54-56	14	156-7	6
60-4	4			51-53	14	154-5	2
55-9	1			48-50	5	152-3	2
50-4	1			45-47	5	150-1	1
45-9				42-44	1	148-9	
40-4	1					146-7	1
35-9	1						

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TABLE I—Continued

Recognition Time		Reading Time		Word Building Speed		Rating on Confidence		A-S	
Step	f	Step	f	Step	f	Step	f	Step	f
680-719	1	140-9	1	1160-1199	1	17	6	22-23	1
640-679		130-9	1	1100-1159		16	5	20-21	1
600-639		120-9	4	1040-1099		15	12	18-19	1
560-599		110-9	2	980-1039		14	23	16-17	1
520-559	1	100-9	1	920- 979		13	37	14-15	1
480-519	3	90-9	2	860- 919		12	38	12-13	5
440-479	3	80-9	11	800- 859	1	11	22	10-11	6
400-439	2	70-9	12	740- 799		10	18	8- 9	7
360-399	10	60-9	14	680- 739		9	14	6- 7	8
320-359	8	50-9	31	620- 679		8	4	4- 5	13
280-319	19	40-9	48	560- 619	1	7	7	2- 3	10
240-279	37	30-9	54	500- 559	4	6	1	0- 1	17
200-239	43	20-9	8	440- 499	2	5	1	-1- 2	17
160-199	34			380- 439	7	4	1	-3- 4	20
120-159	28			320- 379	6	3		-5- 6	20
				260- 319	14	2		-7- 8	17
				200- 259	24	1		-9-10	19
				140- 199	40			-11-12	12
				80- 139	67			-13-14	6
				20- 79	22			-15-16	3
								-17-18	2
								-19-20	2

All of these were distributions of time scores. The skewness, it seems reasonable to assume, may be due to a discrepancy between the physical time scale, which was used in computing the scores, and the psychological time scale. Since the measurements are intended to be psychological, the scales used should be psychological scales. No means is available, however, for determining the psychological units of a time scale. The most logical correction to make was to assume that the true distributions would be roughly normal and to force the scores into approximately normal distributions. This was accomplished as follows: The cumulative frequency curve for 189 cases was divided into fifteen steps, according to a table of the area of the normal curve (13, 530 ff.). The upper limits of each step of this cumulative frequency curve were then used to determine new steps for the actual distributions of scores. Where necessary the upper limits were calculated by linear interpolation. In four instances cases were bunched at the upper end of the distribution. This occurred only in those tests in which an arbitrary limit had been set; namely, the shock, pressure, word building, and perceptual ability

tests. In each of these cases all of the scores which fell at the limit were assigned the median value of the steps which were massed at the limit; in three instances this value was 14, and in one it was 13.

The adjustment of normalizing the distribution was made for all the tests which had time scores. This seemed justified by the facts. In the pressure and shock tests, for example, several Ss had reported that toward the end of a trial the pain did not seem to increase much—suggesting that adaptation occurred so that the increment in discomfort was not proportional to the increment in time. Apart from such evidence, it did not seem wise to calculate correlations from the uncorrected distributions, because to do so would give undue weight to the few extreme scores.

There was no satisfactory *a priori* method of determining the steps for amount accomplished on the perceptual ability test. The points at which Ss gave up on the test, however, fell into ten fairly distinct clusters. Forty-four cases were clustered at one extreme where an arbitrary limit had been set to the score by the fact that the material became nonsensical. The scores, therefore, were grouped into eleven steps; to correct for the bunching of cases at the upper extreme, all the latter were placed in the eleventh step and no cases were placed in the tenth step.

Reliability of the tests. In a study of this sort it is not necessary that the tests used be highly reliable. It is, none-the-less, of interest to know the reliability of the test. Of the ten performance test scores for persistence in the battery, it was possible to calculate split-half reliability coefficients for five. Table II gives the coefficients for the halves of each test and the estimated coefficient for the whole test. The halves used were for the breath holding test the first two trials against the last two, for the motor inhibition test the second trial against the third (the first trial being a practice trial), for the other three tests the right hand trials against the left hand trials.²³

²³ If, before the coefficients of reliability are computed, the distributions are normalized as described above, the correlations between halves of the tests, in the order presented in Table II, are as follows: .876, .935, .954, .895, .710. These yield the following reliabilities for the whole tests, respectively: .934, .966, .976, .945, .830.

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It would be possible to find a split-half reliability also for the shortened form of Wang's questionnaire. This has not been done. Since the form used in this study contains the most diagnostic of Wang's items, it is likely that the reliability is not much less than that reported by Wang for the complete test (.912) (27, 83).

TABLE II
RELIABILITIES OF 5 TESTS OF PERSISTENCE

Test	r Between Halves	Estimated Reliability*
Breath. . . . .	.897	.946
M. Inhibition . . . . .	.907	.951
Shock . . . . .	.896	.945
Pressure. . . . .	.915	.956
M. Grip . . . . .	.740	.851

* Estimated by Spearman-Brown prophecy formula.

In the case of those tests for which reliabilities have not been calculated, some evidence concerning their reliability can be obtained by calculating their respective communalities. The reliability coefficient for each test would be at least as high as the communality of that test. In most cases the reliability would be considerably higher than the communality.²⁴

*Intercorrelations of the items.*²⁵ The chief interest in this study is in the relationships between the 22 items and the meaning of these relationships. The simple intercorrelations between all of the 22 items included in the study are given in Table III. The remainder of the section will present an analysis of these intercorrelations.

There are 231 coefficients presented in Table III. Of these 58 are statistically very significant (underlined); 32 additional coefficients are significant (in heavy type).²⁶ In other words,

²⁴ The reliability is equal to the sum of the variance due to common factors plus the variance due to specific factors. The communality includes only the former. (13, 477. See especially formula 228.)

²⁵ There is no good term to use in referring to both tests and other means of measurement. In the succeeding pages the term *items* will be used in referring to the 22 tests and other measures used in this study.

²⁶ With the exception of coefficients involving sex item, coefficients above .143 are significant, and coefficients above .188 are very significant (13, 549). In determining significance of the tetrachoric coefficients (those with sex as one variable), the above values for significance were multiplied by 1.5 (12, 376).

TABLE III
MATRIX OF SIMPLE INTERCORRELATIONS OF TWENTY-TWO ITEMS* †

Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Breath		-023	<u>223</u>	<u>210</u>	<u>236</u>	<u>358</u>	<u>157</u>	<u>403</u>	<u>433</u>	<u>362</u>	<u>128</u>	<u>108</u>	<u>076</u>	<u>472</u>	<u>748</u>	<u>202</u>	<u>463</u>	<u>127</u>	<u>-154</u>	<u>-004</u>	<u>-051</u>	<u>168</u>
2. Aiming Time			<u>023</u>	<u>147</u>	<u>055</u>	<u>142</u>	<u>134</u>	<u>040</u>	<u>026</u>	<u>011</u>	<u>-165</u>	<u>-019</u>	<u>064</u>	<u>-137</u>	<u>-118</u>	<u>-094</u>	<u>-098</u>	<u>027</u>	<u>035</u>	<u>073</u>	<u>-088</u>	<u>-117</u>
3. M. Inhibition				<u>253</u>	<u>109</u>	<u>328</u>	<u>157</u>	<u>046</u>	<u>113</u>	<u>049</u>	<u>118</u>	<u>080</u>	<u>109</u>	<u>117</u>	<u>044</u>	<u>-089</u>	<u>060</u>	<u>037</u>	<u>003</u>	<u>-134</u>	<u>017</u>	<u>147</u>
4. Perceptual Time					<u>512</u>	<u>560</u>	<u>250</u>	<u>079</u>	<u>177</u>	<u>049</u>	<u>043</u>	<u>178</u>	<u>060</u>	<u>084</u>	<u>098</u>	<u>056</u>	<u>143</u>	<u>259</u>	<u>-172</u>	<u>-125</u>	<u>127</u>	<u>169</u>
5. Perceptual Amount						<u>303</u>	<u>425</u>	<u>087</u>	<u>149</u>	<u>099</u>	<u>-026</u>	<u>104</u>	<u>290</u>	<u>087</u>	<u>153</u>	<u>-020</u>	<u>072</u>	<u>067</u>	<u>115</u>	<u>236</u>	<u>144</u>	<u>138</u>
6. Word Building Time							<u>573</u>	<u>150</u>	<u>299</u>	<u>050</u>	<u>017</u>	<u>028</u>	<u>013</u>	<u>202</u>	<u>325</u>	<u>053</u>	<u>155</u>	<u>278</u>	<u>-125</u>	<u>-184</u>	<u>187</u>	<u>094</u>
7. Number Words								<u>078</u>	<u>181</u>	<u>-046</u>	<u>-119</u>	<u>-068</u>	<u>324</u>	<u>147</u>	<u>205</u>	<u>012</u>	<u>028</u>	<u>067</u>	<u>091</u>	<u>442</u>	<u>105</u>	<u>049</u>
8. Shock									<u>772</u>	<u>428</u>	<u>129</u>	<u>046</u>	<u>017</u>	<u>614</u>	<u>799</u>	<u>453</u>	<u>491</u>	<u>110</u>	<u>-160</u>	<u>001</u>	<u>-017</u>	<u>148</u>
9. Pressure										<u>420</u>	<u>038</u>	<u>002</u>	<u>034</u>	<u>461</u>	<u>606</u>	<u>351</u>	<u>389</u>	<u>206</u>	<u>-156</u>	<u>017</u>	<u>040</u>	<u>092</u>
10. Maintained Grip											<u>059</u>	<u>051</u>	<u>-038</u>	<u>159</u>	<u>198</u>	<u>107</u>	<u>111</u>	<u>073</u>	<u>-069</u>	<u>026</u>	<u>004</u>	<u>130</u>
11. Wang												<u>402</u>	<u>-046</u>	<u>152</u>	<u>136</u>	<u>127</u>	<u>131</u>	<u>031</u>	<u>-073</u>	<u>-040</u>	<u>352</u>	<u>394</u>
12. Rating Persistence													<u>-033</u>	<u>099</u>	<u>151</u>	<u>114</u>	<u>036</u>	<u>012</u>	<u>-041</u>	<u>-046</u>	<u>273</u>	<u>310</u>
13. Verbal Ability														<u>020</u>	<u>-063</u>	<u>-029</u>	<u>004</u>	<u>028</u>	<u>478</u>	<u>402</u>	<u>034</u>	<u>000</u>
14. Grip															<u>960</u>	<u>618</u>	<u>735</u>	<u>140</u>	<u>-180</u>	<u>013</u>	<u>144</u>	<u>195</u>
15. Sex																<u>694</u>	<u>896</u>	<u>235</u>	<u>-343</u>	<u>-078</u>	<u>305</u>	<u>185</u>
16. Weight																	<u>613</u>	<u>050</u>	<u>-075</u>	<u>005</u>	<u>076</u>	<u>181</u>
17. Height																		<u>136</u>	<u>-179</u>	<u>-073</u>	<u>100</u>	<u>184</u>
18. Recognition Time																			<u>-175</u>	<u>-100</u>	<u>004</u>	<u>058</u>
19. Reading Speed																				<u>367</u>	<u>-031</u>	<u>-066</u>
20. Word Building Speed																					<u>003</u>	<u>-012</u>
21. Rating Self-Confidence																						<u>283</u>
22. A-S																						

* Decimal points are omitted.

† Coefficients above .188 (except for sex) are very significant; these are underlined. Coefficients above .143 are significant; these are in heavy type.

a total of about 39% of the intercorrelational coefficients are statistically significant.

Factor analysis of the intercorrelations. The intercorrelations were factorized by means of Thurstone's technique of multiple factor analysis.²⁷ The analysis was continued until six centroid factors had been extracted.²⁸ The centroid loadings of these factors in each of the 22 items are given in Table IV.

TABLE IV
CENTROID FACTOR LOADINGS *

Items	Factors					
	I	II	III	IV	V	VI
1. Breath	648	-140	-225	087	073	-115
2. Aiming	-052	121	-271	042	-089	109
3. Inhibition	255	252	-103	220	045	-235
4. Perceptual Time	453	445	-152	223	-352	-143
5. Perceptual Amount	342	434	-264	-181	-054	-094
6. Word Time	531	374	-264	179	-404	155
7. Number Words	274	431	-371	-365	-206	267
8. Shock	648	-422	-256	-045	215	201
9. Pressure	636	-268	-401	031	202	229
10. Maintained Grip	307	-164	-251	180	351	053
11. Wang	309	159	447	126	365	068
12. Rating Persistence	271	236	372	131	195	049
13. Verbal Ability	038	356	-290	-466	247	-190
14. Grip	752	-357	103	-325	-061	-092
15. Sex	911	-483	097	-331	-157	186
16. Weight	499	-345	194	-290	-070	-041
17. Height	676	-372	138	-255	-147	-224
18. Recognition Time	275	043	-082	155	-181	072
19. Reading Speed	-247	278	-158	-412	327	-201
20. Word Speed	-060	207	-207	-525	246	115
21. Rating Self-Confidence	293	271	398	-104	052	278
22. A-S	396	218	321	074	236	-029

* A decimal point should precede each number.

Centroid factor loadings are not expected to yield psychologically meaningful interpretations. It is necessary first to rotate the axes; the factors then may become psychologically meaningful. The process of rotation followed in this analysis

²⁷ For a description of this technique and of the procedure followed in the present analysis, see Guilford (13, 457-514).

²⁸ At this point the standard deviation of the residuals was about 60% as large as the standard deviation of the average original correlation; the largest residual was $-.173$, and only eight residuals (of 231) were as high as $.100$; the largest loading of any variable in the 6th factor was $.278$, which represents a communality of only $.0773$.

† Coefficients above .188 (except for sex) are very significant; these are underlined. Coefficients above .143 are significant; these are in heavy type.

was that described by Guilford (13, 502 ff.) for the rotation of successive pairs of axes. The loadings of the 22 items for each pair of factors were plotted on a graph. The rotation to be made was determined by inspection of the graphs. The criteria used in deciding which rotation to make were: (1) getting axes that run through clusters of points, and (2) maximizing the number

TABLE V
FACTOR LOADINGS AFTER ROTATION *

Items	Factors					
	I	II	III	IV	V	VI
1. Breath	405	264	473	031	033	-237
2. Aiming	097	193	-145	-188	028	095
3. Inhibition	123	336	-029	157	052	-300
4. Perceptual Time	-019	759	089	092	-051	-167
5. Perceptual Amount	051	512	087	046	381	-003
6. Word Time	131	800	175	-008	-111	102
7. Number Words	049	551	100	-132	382	408
8. Shock	615	-001	609	-049	008	043
9. Pressure	685	161	474	-085	040	051
10. Maintained Grip	554	-015	127	040	025	-129
11. Wang	128	-051	098	669	-033	-008
12. Rating Persistence	035	089	052	558	-052	001
13. Verbal Ability	017	130	-054	-014	712	-002
14. Grip	097	049	890	087	092	-057
15. Sex	213	088	1.073	050	-060	177
16. Weight	-017	-078	697	079	020	008
17. Height	-014	048	844	049	024	-185
18. Recognition Time	103	299	142	-009	-160	004
19. Reading Speed	-074	-123	-242	-002	634	-018
20. Word Speed	046	-050	-037	-043	589	292
21. Rating Self-Confidence	-072	135	144	513	001	318
22. A-S	087	119	166	561	040	-070

* A decimal point should precede each number except 1.073.

of loadings of less than .100. Eighteen successive rotations were carried out. The final rotated factor loadings for each item are given in Table V.²⁰

The amount of the total variance of each test that is accounted

²⁰ Each factor loading may be interpreted as indicating approximately the correlation between the item and the factor in question. That these loadings are only approximations of the degree of relationship is emphasized by the fact that sex has a loading of more than unity in Factor III. The error in the approximation in this case is probably the result of using tetrachoric coefficients in determining the relationship between sex and the other items. These coefficients are probably too high because of the fact that sex yields a discrete rather than a continuous distribution. The distortion that has resulted, however, is one of degree and not of great importance.

for by a given factor is indicated by the square of the loading for the test. The sum of the squares of all the loadings for a given item represents the communality of the item, that is the amount of the total variance of the item that is accounted for by the factors common to the group of items. In order to conserve space, these squares and communalities are not presented here. The following items have relatively high communalities: sex, grip, shock, pressure, height, time on word building, time on perceptual test. These have low communalities: aiming, motor inhibition, recognition time.

Evidence of validity of the factor analysis. The interpretations and conclusions in this paper are based largely on the results of the factor analysis. It is fitting to consider briefly whether this analysis is valid. In the next few paragraphs a comparison is made between the results indicated by factor analysis and the results suggested by the original table of simple intercorrelations (Table III). This comparison indicates that the findings disclosed by the two approaches are in harmony.

It may be seen in Table V that no factor has appreciable weightings in all the tests which were intended to measure persistence, *i.e.*, there is no factor universal to these tests. It may also be seen that the self-estimates of persistence (items 11 and 12) have no significant weightings in any of the factors that have important weightings in the performance tests.

These facts might have been predicted on the basis of the intercorrelations found in Table III. Items 11 and 12 are correlated with each other; but neither shows important correlations with the performance tests which were intended to measure persistence (items 1-10). When the 45 intercorrelations for items 1 to 10 are considered, it is apparent that there must be some common factors, since 19 of the 45 coefficients are very significant and seven more are significant; but the 19 coefficients which are not significant indicate that there can hardly be a single factor that is important in all the ten items.³⁰

³⁰ It is possible, but far from probable, that a common factor might be present in all of the tests and yet nineteen correlations might be insignificant because of the masking effect of other factors common to some of the tests, as demonstrated in an earlier section.

Not only do the intercorrelations found for items 1 to 10 indicate that there probably is not a universal factor present; the significant coefficients appear to fall into two groupings. Items 8, 9, and 10 correlate highly with each other, and items 4, 5, 6, and 7 correlate highly with each other; but the correlations for items 8, 9, and 10 with items 4, 5, 6, and 7, respectively, are consistently low and for the most part statistically not significant. Item 1 correlates significantly with both groups of items. These facts would lead one to expect to find one factor common to items 8, 9, 10 and 1 without significant loadings for items 4, 5, 6, and 7, and another factor common to items 4, 5, 6, 7, and 1 without significant loadings for items 8, 9, and 10. An inspection of Table V indicates that these expectations based upon the simple intercorrelations are confirmed by the findings of factor analysis. Factor I has weightings in items 8, 9, 10 and 1, and negligible weightings in items 4, 5, 6, and 7. Factor II has weightings in 4, 5, 6, 7, and 1 and only negligible weightings in items 8, 9, and 10.

The results of the factor analysis indicate that there are five common factors that have important weightings in certain of the tests (*cf.* Table V). The significant coefficients in Table III indicate that there must be factors common to some of the tests. The question arises: Do the factors found by the analysis reveal real patterns of interrelationships that are present in the original intercorrelations? The simplest way to answer this question is to pick out those items that are loaded with a given factor and see whether they have consistently significant intercorrelations.³¹

Tables VI-X present the facts. In each table are presented the intercorrelations for all of the items that have loadings above .35 for the given factor.³² All of the coefficients are positive and most of them relatively high; 47 of the 49 coefficients are statistically very significant.³³ These facts are to be compared with

³¹ Allowance should be made for an occasional case in which the relationship is masked by the presence of common factors working in opposite directions.

³² Factor VI has no high loadings. No attempt will be made to interpret this factor; hence, its reality is not considered here.

³³ *Cf.* footnote 26.

the similar facts for the intercorrelations of all the items (Table III): Of 231 coefficients, 58 are very significant; 47 coefficients are negative.

TABLE VI
INTERCORRELATIONS OF ITEMS WITH HIGH LOADINGS IN FACTOR I

Items	8	10	1
9	.772	.420	.433
8		.428	.403
10			.362

TABLE VII
INTERCORRELATIONS OF ITEMS WITH HIGH LOADINGS IN FACTOR II

Items	4	5	7
6	.560	.303	.573
4		.512	.250
5			.425

TABLE VIII
INTERCORRELATIONS OF ITEMS WITH HIGH LOADINGS IN FACTOR III

Items	14	17	16	8	1	9
15	.960	.896	.694	.799	.748	.606
14		.735	.618	.614	.472	.461
17			.613	.491	.463	.389
16				.453	.202	.351
8					.403	.772
1						.433

TABLE IX
INTERCORRELATIONS OF ITEMS WITH HIGH LOADINGS IN FACTOR IV

Items	22	12	21
11	.394	.402	.352
22		.310	.283
12			.273

TABLE X
INTERCORRELATIONS OF ITEMS WITH HIGH LOADINGS IN FACTOR V

Items	19	20	7	5
13	.478	.402	.324	.290
19		.367	.091	.115
20			.442	.236
7				.425

The conclusion indicated is that factor analysis has served to reveal real patterns of interrelationships which are present in the

original intercorrelations; *i.e.*, the items which are loaded with a given factor are consistently interrelated with each other. The interpretations of the factors in the next section, therefore, may be considered valid interpretations of the actual interrelationships found in the original correlations. It is to be remembered, of course, that all of the interpretations are based upon correlations, and are limited by that fact.

INTERPRETATIONS AND CONCLUSIONS

Absence of a universal factor. A battery of performance tests representative of those purporting to measure persistence was administered individually to 189 Ss. The tests were all given in one session and with the same set of incentives for the whole battery—conditions favorable to the finding of a factor universal to the tests. The correlations were treated by factor analysis in an effort to reveal any universal factor that might be present but masked by other factors common to some of the tests. In spite of these favorable conditions, and whether factorized or not, the intercorrelations between these supposed tests of persistence do not reveal evidence of any universal factor. Nor do the data reveal evidence of a factor common to the self-estimates of persistence (questionnaire or rating scale) and any of the above performance tests.

In these respects the data agree with the findings of Porter (20) and Henninger (15)³⁴ who applied a somewhat different battery of tests to 40 Ss³⁵ and on the basis of intercorrelations drew conclusions concerning two points: (1) whether there is a generalized trait of persistence; (2) whether the proposed tests of persistence are valid. The writer cannot concur, however, in the conclusions stated by Porter and Henninger. These con-

³⁴The study was done by Mr. Henninger under the direction of Professor Porter. The reference cited above for Porter is the latter's report of the same study.

³⁵Four hundred ten Ss were used in preliminary experimentation with various of the tests. The experimental group to whom the whole battery was administered, however, included only 40 Ss. The intercorrelations reported are based on these 40 cases.

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clusions appear to the present writer to be broader than is warranted by either the present or the previous findings.³⁶

Factors disclosed by the analysis. Although the data fail to reveal a factor universal to the tests, they do reveal the presence of at least five common factors, which are mutually independent.³⁷ Two of these factors bear a resemblance to certain aspects of persistence. These are discussed first.

Factor I (see Table V) has fairly high loadings in the following tests:

Pressure.....	.685
Shock.....	.615
Maintained grip.....	.554
Holding breath.....	.405

³⁶ Concerning the results Porter (20) states: "The picture revealed by some 350 coefficients of correlation, zero order, partial and multiple, is one of almost complete lack of positive relationship among tests which have been considered valid tests of persistence." And Henninger (15, 53) concludes: "Two indications seem fairly clear: that persistence is not a generalized trait, and that some of the tests advanced as tests of persistence are not, in their present form, valid tests of it."

It is difficult to see how Henninger can conclude *both* that persistence is not a generalized trait and that some of his tests are not valid, since the one conclusion precludes the other. If the tests used were not valid as measures of persistence, then the study provides no adequate evidence concerning the presence of a generalized trait of persistence. If, on the other hand, there is no generalized trait, there is no reason to expect high intercorrelations between the tests.

Even Porter's conclusion seems scarcely justified by their findings. In Table VIII in his thesis Henninger presents the 45 simple intercorrelations between his ten measures of persistence. These correlations, it will be remembered, are based upon only 40 cases. When Fisher's test of statistical reliability is applied, it is found that 8 of the 45 coefficients are "very significant" and 3 more are "significant" (13, 548-9). All of the eight very significant coefficients are positive; these range in size from .42 to .81.

The findings of Porter and Henninger are in harmony, however, with the conclusion stated for the present study, that there is no evidence of a factor *universal* to the supposed tests of persistence.

³⁷ There is some question concerning the complete independence of Factor III from Factors I, II, and IV, respectively. They are nearly independent, and the weightings given them are based upon the assumption of their independence.

It is interesting to note that Henninger's intercorrelations show the following patternings suggestive of certain factors found in this study: (1) Three time scores for tasks which permit S to keep on (without suffering bodily discomfort) are interrelated. (2) Two tasks in which S keeps on at the cost of increasing discomfort are interrelated. (3) Wang's questionnaire (modified) and a self-rating scale on persistence are correlated.

These tests have in common the fact that increasing the score entails withstanding discomfort—pain in the shock and pressure tests, fatigue and exhaustion in the maintained grip and holding the breath tests. All other items in our battery have negligible weightings in this factor. This factor quite clearly involves withstanding discomfort and is tentatively designated as WD—an ability and/or a willingness to withstand discomfort in order to achieve a goal. Possibly it is a decreased sensitivity to conditions which arouse sensations of discomfort.

Three of the tests which have heavy loadings in WD were taken from Howells' battery. These three tests (shock, pressure, maintained grip) comprise almost his entire battery. The present data, therefore, present confirmation of Howells' assumption that his tests measure a real variable of behavior. It is doubtful, however, whether Howells is justified in calling the variable persistence. The factor has practically zero weightings in rating on persistence, Wang's questionnaire, and the verbal tests which have been assumed to measure persistence. It is, therefore, better labeled WD.

The other factor that resembles an aspect of persistence is Factor II. (See Table V again.) This has loadings in the following items:

Time on word building test.....	.800
Time on perceptual ability test.....	.759
Number of words built.....	.551
Amount read in perceptual test.....	.512
Motor inhibition.....	.336
Holding the breath.....	.264
Time on verbal recognition test.....	.299

The amount read on the perceptual ability test and the number of words obtained in the word building test both depend quite heavily upon the amount of time spent at these tasks; their loading in this factor, therefore, may be considered a function of the time scores for the same tests. All of the scores in this group, then, may be considered time scores. The two tests that are by far the most heavily loaded with the factor both give opportunity for S to keep working at a task upon his own volition, or to stop upon his own initiative. The factor apparently does not involve

greater motivation; it has no weighting in shock or maintained grip, the scores on which would be affected by the degree of motivation. It does not imply keeping on at the expense of discomfort; for, again, such a factor should have weight in the maintained grip and shock tests. Probably the factor is not an interest in verbal material, for it has appreciable loadings in motor inhibition and holding the breath, and only a slight loading (.130) in verbal ability.

The evidence suggests that this factor involves a quality of patience or willingness to spend time at a task, perhaps a lack of pressure to activity or a lack of demand for a change. These in general are the characteristics of a plodder. Further light is thrown on the nature of the factor by the fact that it has no loading in the self-rating scale for persistence or in Wang's questionnaire. Both of the latter emphasize the idea of not giving up. Persons with much of Factor II apparently do not think of themselves as giving up less readily than others. This suggests that the fundamental factor here is a difference in evaluation of time so far as one's own activity is concerned. The person with much of this factor is characterized not by greater determination to reach a goal—in this he is no different from the average, but rather by greater willingness to spend time in accomplishing a task.

The verification of this tentative identification of Factor II and the determination of its importance in other tasks must await further experimentation. In the meantime it may be referred to as *Pl*.

The remaining factors do not involve persistence, but their appearance in a battery of tests designed to measure persistence gives them importance in this study. Factor III has large positive loadings in these items:

Sex	1.073 ⁸⁸
Grip . . . . .	.890
Height . . . . .	.844
Weight . . . . .	.697
Shock . . . . .	.609
Holding breath . . . . .	.473
Pressure . . . . .	.474

⁸⁸ Cf. footnote 29.

What is common to these items? Grip, obviously, is a matter of strength. Height and weight and sex are related to differences in strength. A good score on the shock test appears to depend somewhat on muscular strength. (The correlation between grip and the shock test was .614. Just why this should be is not obvious. Observation of the Ss taking the shock test, however, suggests that the person with stronger hands finds the shock easier to take. Perhaps larger and more developed muscles are less easily stimulated by electric current. Or, perhaps, the person with the more muscular hand is better able by voluntary effort to resist the tendency for the little muscles of the hand to become painfully cramped as the current increases.) Holding the breath requires inhibition of the natural breathing responses. This means muscular effort, as is quite evident when one observes on individual holding his breath. The pressure tests do not appear to demand muscular activity; yet common observation indicates that toughness of tissues usually accompanies muscular development. The conclusion seems indicated that Factor III involves physical strength. Whether it involves also other sex factors is not evident, although the very high loading for sex makes this seem likely. Tentatively the factor is labeled a *sex-strength* factor.

Factor IV has large positive loadings in four tests:

Wang questionnaire .....	.669
A-S test .....	.561
Rating on persistence.....	.558
Rating on self-confidence.....	.513

It has near-zero loadings for the various verbal tests, shock and pressure tests. Logical analysis of the items in the Wang questionnaire and also in the ascendance-submission test suggests that many of them, especially in the Wang test, depend upon S's feeling of adequacy or self-assurance in the situations suggested. For this factor is proposed the description *feeling of adequacy (FA)*. This description is in partial agreement with Stagner's conclusion that the Wang test measures self-confidence or self-assurance (18, 226). The slight negative loading in aiming time (-.188), though unconvincing, fits in with this interpre-

tation of the factor; the individual who feels less adequate will hesitate longer before risking a test. Perhaps this factor represents a halo effect in S's estimate of himself. The apparent halo effect, however, may well be considered a function of the feeling of adequacy. This description of FA must be considered only tentative. More confidence might be placed in the interpretation if the factor had larger loadings in performance tests. The interesting point, however, is that there is in these supposedly different scales and questionnaires a common factor with as much weighting as is found for Factor IV.

Factor V has positive loadings as follows:

Verbal ability .....	.712
Reading speed .....	.634
Word building speed.....	.589
Number of words built.....	.382
Amount read on perceptual.....	.381

There is a slight negative weighting ($-.160$) of this factor in time spent at verbal recognition. The remaining items have almost zero loadings. The individual who has a large amount of Factor V, then, would make a good score on the verbal parts of the Army Alpha Examination (which is a timed test), would build words more rapidly, would build somewhat more words, would read rapidly and somewhat further in the "scrambled" passage, and would check the recognition list slightly more rapidly. Clearly the pattern suggests a mental fluency of some sort, probably a verbal fluency.

Thurstone (24, 84-5) has factorized the intercorrelations of a large group of tests that included a wide variety of verbal tests. He reports two verbal factors: "verbal relations" (V), which involves use of ideas and meanings of words; and "W" which "seems to have as its principle characteristic a fluency in dealing with words."

Thurstone's tests and the verbal tests in the present battery have enough in common to suggest that the factors found should be related. Included in Thurstone's battery were anagrams, disarranged sentences (adapted from the Army Alpha), vocabulary tests, inventive opposites and synonyms. The anagrams test was similar to the present word building; disarranged sentences

comprised 40 per cent of the present verbal ability test, and a "same-opposite" vocabulary test comprised another 40 per cent of it. Those of Thurstone's tests mentioned in this paragraph are weighted with both of his verbal factors (V and W). It is possible, therefore, that the present Factor V represents a dimension located between Thurstone's two verbal factors.

Thurstone concludes that his W factor does not involve other forms of fluency than word fluency—this conclusion in spite of the fact that subtraction and multiplication tests have weightings in W of .298 and .284, respectively, and the largest weighting in the factor is .534 (24, 115-6). Since the present battery included no non-verbal tasks that might involve fluency, the writer hesitates to specify that Factor V is limited to verbal material; he prefers for the time being to call it simply a mental fluency factor (*F*). This tag is attached with reservations; it is possible that the primary factor here is familiarity with verbal material (verbal knowledge) or verbal ability and that the apparent fluency is a result.

Factor VI does not appear clearly enough indicated to justify an attempt to interpret it.

To summarize the evidence concerning what factors are measured by the tests that have been considered tests of persistence: Some of the performance tests (principally those from Howells' battery) measure in part WD (an ability and/or willingness to withstand discomfort in order to reach a goal). The scores on most of these same tests are influenced about equally by a sex-strength factor. On others of the performance tests, principally the word building and perceptual ability tests, the scores are determined in part by a keeping on factor (PI). The scores which represent amount accomplished on the word building and perceptual ability tests depend partly upon a mental fluency factor; but the time scores do not. The latter are the more heavily weighted with PI. The time scores, therefore, are the better indicators of PI;³⁹ and it is probable that the other scores

³⁹ Chapman in his word building test, used the time score as a measure of persistence. Hartshorne, May, and Maller in their Stories Test used a score more or less equivalent to a time score.

measure PI only in so far as they are functions of the time scores. The self-rating scale and questionnaire intended to measure persistence are not weighted with either WD or PI; but they are weighted with a factor that is common to the two rating scales and the two questionnaires. This factor has no large weightings in the performance tests, and it is tentatively identified as "feeling of adequacy." All of these factors are identified with reservations.

Possible practical importance of WD and PI. The WD and PI factors may prove of practical importance. Howells has already presented evidence of a relationship between his battery, which seems in part a measure of WD, and grades in college. One might expect a similar relationship between grades and PI. Since many situations in the occupational world demand *withstanding discomfort* and *keeping on* patiently, one might venture the prediction of a relationship between these factors and success in certain occupations. If such relationship should be found, tests of these factors could be developed which might prove of as much practical importance in predicting performance as the present intelligence tests.

Bearing of results on Howells' battery. Although apparently believing he was testing persistence, Howells has already developed a battery of tests which show promise as measures of the WD factor. The present data suggest the possibility that the battery might be improved by the addition of a test of holding the breath. Howells has recorded reliabilities for his whole battery, ranging from .87 to .92, but he has reported no reliabilities for test units. The present results indicate reliabilities for the test units that were used which, with the exception of the maintained grip, are higher than the reliabilities reported by Howells for the whole battery.⁴⁰ Howells considered the pressure tests as the most adequate single unit in his battery. The data of this study indicate that the shock test is about equally good; the weightings in WD and the reliabilities of the two tests are similar. The shock test has two advantages over the pressure tests: it requires less time; there is less danger of permanent injury. Howells' con-

⁴⁰ Cf. *ante*, Table II.

clusion was probably due to the spuriously high correlation which he found between the scores on the pressure tests and the composite score for his whole battery—spuriously high because the scores on the pressure tests constituted such a large part of the composite score.

Howells recognized the possibility of a physical factor influencing his scores but erroneously assumed that the correlation between his scores and weight was an adequate check upon this factor. By this check he determined that a correction of only 20 per cent was needed for the pressure scores and no correction was needed for the other scores. In the present data, where sex, strength of grip, and height as well as weight are taken into consideration, it is evident that a physical factor plays an important part in the determination of the scores for the shock test, even more than for the pressure tests. The data suggest also the items which need to be taken into account in determining a correction or differential norms for the shock and pressure scores. In the light of these findings it would seem possible by use of a proper number of trials of pressure, shock, and maintained grip tests, with proper correction of the scores for the sex-strength factor, to determine with some degree of accuracy an individual's score on the WD factor. The next step is to determine the importance of such a measure in predicting an individual's performance in given tasks.

To summarize, the present data (based upon a larger group of Ss) confirm the value of Howells' tests as a measure of a real variable of personality. They raise a question, however, concerning Howells' assumption that this variable is persistence. Further, these data indicate the importance of a physical sex-strength factor in the determination of the scores on Howells' tests and emphasize the need for correction of the scores for this factor; this, Howells only inadequately recognized. The present analysis indicates the items which need to be considered in determining this correction. It also yields evidence concerning the relative value of the various parts of Howells' battery and indicates an additional test which might be included.

Suggestions for further investigations. The finding of a common factor in the two questionnaires and the two self-rating

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scales used in this study, suggests the need for further research to determine more precisely the nature of this factor and its importance in various performances. The hypothesis is advanced that there is a factor common to types of behavior which have been described as self-confident, self-assured, ascendant, determined, self-assertive and (perhaps) persistent. This hypothesis could be tested by the factor analysis of a battery of tests which included both performance and self-rating types of tests for the above characteristics of behavior. The battery ought also to include some measures of physical factors to test the possibility of the dependence of the hypothesized factor upon physical drive or adequacy.

A question was raised earlier as to whether the fluency factor is a *verbal* fluency only. This question could be answered experimentally by a factor analysis of a battery of tests chosen so as to include some verbal and some non-verbal tasks which would give opportunity for the fluency factor to influence the score. Thurstone's study (24) already gives a partial answer to the question. It seems desirable, however, to make another attempt with selection of tasks more specifically intended to measure fluency. One task which might be included is Clark's number building (5).

A more basic problem concerning the fluency factor is whether it is an ability or a predisposition, or a combination of the two. Some Ss appear to have a predisposition to work rapidly and intensely at a task. Is this apparent predisposition simply a reflection of the ability to work rapidly, or is it a separate factor? Evidence on this problem could be gained from a simple experiment. Let a group of Ss work at a given task, for example, the deciphering of a "scrambled" passage or word or number building, under two conditions: (1) working at their own speed under the impression that time does not count; (2) working under a speed set (with instructions that the score depends upon speed). If the differences in speed under condition 1 represent only differences in ability to work rapidly, then rapid and slow workers should show similar increase in speed under condition 2. If, on the other hand, the differences in speed represent partly predis-

position to work rapidly, the slow Ss under condition 1 should show relatively greater increase in speed under condition 2.

The possible importance of the PI factor would seem to justify additional experimentation to discover how widespread is the occurrence of this factor. Such experimentation might aim at the discovery of the importance of PI in untimed tests when the tasks set are solving puzzles, number building, maze tracing, and tasks requiring motor dexterity. There is also need to determine the relation between PI and performance in everyday tasks—as in school and various occupational situations.

SUMMARY

(1) A battery of performance tests (yielding ten scores), a self-rating scale, and a questionnaire, all purporting to measure persistence, were administered to 189 students from the beginning course in psychology. Intercorrelations were calculated for the above twelve items and ten other measures. These intercorrelations, of every item with every other item, are presented in Table III.

(2) The intercorrelations were analyzed by Thurstone's multiple factor methods. The results of the factor analysis are compared with the evidence yielded by direct logical analysis of the original correlations. The relationships indicated by the two sets of findings prove to be in harmony.

(3) The analysis did not reveal the presence of any factor universal to the tests. In other words, the tests which purport to measure persistence do not all measure the same thing. Nor did the analysis reveal a factor common to the self-estimates of persistence and any of the performance tests.

(4) The analysis did reveal the presence of five approximately independent factors that are important in the tests studied. These factors are identified tentatively as (1) withstanding discomfort to achieve a goal (WD), (2) keeping on at a task (PI), (3) sex-strength, (4) feeling of adequacy, (5) mental fluency.⁴¹

⁴¹ The author explicitly recognizes that the interpretation of the factors has validity only in so far as it is possible to infer causal relationships on the basis of intercorrelations. This is a limitation of all factor studies. Specifically, the possibility must be recognized that correlations may be influenced by unintentional non-representative selection of cases.

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Of these the first four are important in tests previously proposed as measures of persistence.

(5) The factors WD and PI are considered of especial interest because of the resemblance they bear to certain aspects of what is generally called persistence. Neither, however, seems properly labeled "persistence," and the two are not intercorrelated.

(6) The possible practical importance of the WD and PI factors and the possibility of developing batteries to measure these factors are suggested. Further investigations, the need for which was suggested by the study, are planned.

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APPENDIX

Perceptual Ability Test (first page)

WAYS AND MEANS

"Murder is seldom pleasant," the tall Westerner replied dryly; "but," he continued, fingering his cigaret lightly, "sometimes it is necessary."

I studied his inscrutable expression, searching for a cue to his meaning. "You mean" I ventured tentatively, "that it may be necessary in this case

who knows? he responded with a careless shrug of the shoulders something in his manner told me that it was futile to say more

I tried to recall what in our conversation had led up to this abrupt ending. We had been chatting as we waited for others of the committee to arrive the conversation had moved naturally from the coming Election with its financial problems to graft in politics I had mentioned the He received scandal in New York then somehow - - -

gentlemen, the voice of the chairman interrupted My thoughts. We have metto plana din nerin honorofou rillu strious sena torfromne Wyo rkin ee dnot rem in dyou th at this dinner may prove important for us. Al. Iwem uesto verl o OKn oth in gnote v enth esm alle std eta il bur ke hav eyo uar ran gedthem en U an dm a deal lot herp re Par at I on. Sye SS Enat oro. Urt rust.

Ed Friedman I like nothing as to end edtoe. We rym a tte. R wed in E.M. on days eve nath. O! tell afar! Get he se rv. Icew, I llb es: up, er - - - - - ; bf I Rstw e l l p; i t chatt? hilltop lec - - ; ho, t - ho, - - U gh, tsa ol da ftg. (Ener als o Lut) I; O no, rit e stf irr it at! Grad efr omstr ines at. plus hotl E.E.R. cu RRE Ntinc.

Rea sedann Unitys, "O ldl 89, latl etu S.S.", ayf rie ndab; sol Ut el ys h

Name.....

RATING SCALE FOR PERSISTENCE

Definition: To persist is to continue trying to accomplish a task in spite of difficulties; to cling to a purpose in spite of counter influences, opposition, or discouragement. This applies to everyday tasks as well as to more remote goals.

Mark with an X the position on the line that best describes your degree of persistence. (Your mark need not be immediately above one of the descriptive phrases; it may be at any point along the line that you think best fits you.)

Extremely persistent. Perserveres in spite of difficulties. Never gives up.	Seldom deterred by difficulties.*	Usually finishes a task before leaving it.	Tends to leave difficult tasks unfinished.	Extreme lack of persistence. Easily deterred by obstacles. Gives up quickly.
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* That is, seldom gives in to difficulties.

Name.....

RATING SCALE FOR SELF-CONFIDENCE

Definition: To be self-confident is to believe in and to rely upon one's own abilities and powers.

Mark with an X the position on the line that best describes your degree of self-confidence. (Your mark need not be immediately above one of the descriptive phrases; it may be at any point along the line that you think best fits you.)

Extremely self-confident. Relies completely on own abilities. Trusts own judgment. Courts responsibility.	Usually relies on own abilities.	Relies on own abilities as often as not.	Seldom relies on own abilities.	Extreme lack of self-confidence. Distrusts own judgment. Afraid to rely on own abilities. Avoids responsibility.
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