

AN ANALYSIS OF THE MINNESOTA VOCATIONAL TEST FOR CLERICAL WORKERS.* I

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THE Minnesota Vocational Test for Clerical Workers has been used extensively at the University of Minnesota Employment Stabilization Research Institute in the study and guidance of workers and in the differentiation of groups of employed and unemployed workers in various occupations. It has been demonstrated (2) that the clerical test differentiates clerical workers from workers in the general population better than an academic ability test, and that it discriminates somewhat less successfully various classes of clerical workers, such as stenographers, from general clerical workers. Another investigator (6) also has reported significant differences in clerical test scores between men office clerks and garage mechanics, and between women office clerks and retail saleswomen. Other findings have shown the Minnesota Clerical Test to be not only a reliable and valid measuring instrument but one which seems to measure an aptitude relatively independent of clerical training and experience (2). To show, however, that a given aptitude test measures clerical

* The contents of this article were taken from the author's Ph.D. dissertation on file in the office of the Graduate School of the University of Minnesota. The author is grateful for the facilities made possible by the Employment Stabilization Research Institute for the additional standardization and study of the Minnesota Clerical Test. She gratefully acknowledges her indebtedness to her adviser, Professor Donald G. Paterson, for guidance during the course of this research. She wishes to express her appreciation to Dr. Charles Bird for offering many helpful suggestions which have aided in the preparation of the manuscript.

ability does not describe clerical ability adequately, nor does it differentiate clerical ability from other measurable abilities.

The aim of this study is not to produce further evidence for the reliability and validity of the test but to find out what abilities the clerical test is measuring, and what abilities it is independent of when applied to a homogeneous group of clerical workers. The problem, which is one of mental organization, can be studied most adequately through an analysis of the intercorrelation of tests devised to measure various abilities. It is important to devise an instrument which adequately measures an ability and it is equally as important to isolate, study, and differentiate that ability from other tested abilities. Progress in mental analysis depends largely upon the measurement and isolation of unique traits. Until such comprehensive studies are made and described, ability tests will aid theoretical psychology little in the understanding of man even though their practical applications may be numerous. Mental analysis studies also have many practical applications. Industrial and educational fields will be aided by analyses of the independence and interrelations of mental traits.

The first problem, then, is to discover what aptitudes the clerical test is measuring or what traits are closely related to the performance it samples. To do this, it will be necessary to select a battery of tests which measure simple abilities so that when the relationships are found it will be possible to single out and discuss the nature of the existing correlation.

In the study of the relation of the clerical test to other abilities, it is important to study also the relationship of the test to other measures of clerical ability. Previous results have shown that the Scott Company's File Clerk's Test and the Hoke Prognostic Test of Stenographic Ability are measuring in part the same abilities as the Minnesota Clerical Test (2). Since the aim of this study is to explain the nature of clerical ability, single tests of relatively simple abilities presumably measuring clerical aptitude will be studied in relation to the clerical test.

The first step, then, in the analysis of any ability is the examination of basic elements which constitute or are related to that ability. In this study, the basic elements will consist of a battery of tests of simple functions, such as dexterity, cancellation, and substitution, as well as of tests of simple arithmetic, spelling, observation and comparison, and number group checking.

A second problem is to determine if the clerical test is measuring a unique trait, that is, one which is relatively independent of other tested abilities. At present the relationship between mechanical aptitude, dexterity, academic ability tests and clerical ability are important considerations. If the clerical test is measuring an ability different from other aptitudes, the test when applied to a group of clerical workers or workers in other occupations must not show high degrees of relationship with other tested abilities. High degrees of relationship would mean that the tests were measuring approximately the same abilities but in a different guise. To warrant existence, each new test must show how it is measuring an ability better than previous tests, and whether it is measuring abilities which are relatively independent of those already being measured.

A final consideration to be considered in a succeeding publication, as revealed by factor analysis techniques, is the question of uniqueness and overlapping of abilities and the number of factors involved in the many tests. The intercorrelations for this analysis will be studied by the Thurstone "Simplified Multiple Factor Method" and by Spearman's technique of tetrad analysis. Factor analysis is considered because of its possible contribution to the understanding of the measured abilities and not for any theoretical considerations aimed to disprove or substantiate the techniques or the various theories of factor analysis.

EXPERIMENTAL PROCEDURE

All of the subjects for this study were employed or unemployed workers who were being tested by the occupational

analysis clinic of the Employment Stabilization Research Institute. The regular battery of tests used by the Institute was administered by the Institute Testing Staff to each subject, whereas the special battery of tests was given by the writer. All subjects were tested individually with both the Institute and the special test batteries. There were 340 workers tested for this study, 216 women and 124 men. Of the 340 workers, 155 women clerical workers were selected to serve as an experimental group.

The occupational classification of the subject was not always known at the time of testing since the occupational interview frequently was not taken until late in the day after the testing had been partially or fully completed. Consequently, the sample consisted of a fairly heterogeneous group with respect to age and occupation. When it became apparent that there were more women in the sample than men, and that the women were a more homogeneous group with respect to age and occupation, the last weeks of testing were restricted to women clerical workers.

The women selected for this study ranged from 17 to 29 years of age. All had had some experience in clerical work with the exception of four who had no work history but who seemed suited to clerical work according to their educational record and test scores. Of the 155 women workers, 139 were employed clerical workers. The others were unemployed.

From the files of the Institute, data were obtained concerning sex, age, usual occupation, occupational history, years of clerical experience, and years of formal schooling.

Among the Institute battery of tests (7) were measures of academic ability, clerical ability, manual, finger, and tweezer dexterities, mechanical ability, personality traits, and vocational interests. Personality and vocational interests scores were not considered important for the present study, and the data in the mechanical assembly test were too incomplete to be useful. All other test scores were used.

TESTS USED

*(a) Institute Battery**Pressey Senior Classification and Verification:*

These tests are measures of academic ability. In this experiment the average of the two test scores was used. The two Pressey Tests correlate about +.90 with each other, an indication that they are measuring approximately the same abilities (13).

*Minnesota Vocational Test for Clerical Workers:*¹

This is a test of clerical aptitude consisting of two parts, a clerical number checking test, and a clerical name checking test.

O'Connor Finger Dexterity Test:

This is a test which measures speed and accuracy in eye-hand coordination. The subject is required to pick up three pins at a time and to place them in each of one hundred holes.

O'Connor Tweezer Dexterity Test:

The tweezer dexterity test measures the speed and accuracy with which the subject can manipulate a pair of tweezers in the picking up and placing of one pin in each of one hundred holes. This test requires a high degree of speed and accuracy in eye-hand coordination and steadiness

Minnesota Manual Dexterity Test (Placing):

This test measures the speed with which the subject can place relatively large circular wooden blocks in holes in a board. "Success is dependent upon speed of gross hand and arm movements." (7)

Minnesota Spatial Relations Test:

This is a test of mechanical ability which is relatively free from the effect of mechanical experience. It is made up of four boards, each board containing 58 cut-outs. It is a

¹ The Minnesota Vocational Test for Clerical Workers is distributed by the Psychological Corporation, 522 Fifth Avenue, New York City. A complete discussion of the nature of and results obtained from the Minnesota Clerical Test is published in a bulletin of the Employment Stabilization Research Institute, entitled "Measured Characteristics of Clerical Workers," written by D. M. Andrew and D. G. Paterson. This bulletin is available through the University of Minnesota Press.

test of speed and accuracy in form perception, since it requires one to discriminate quickly and accurately various odd shapes and sizes.

In the final set-up, thirteen additional special tests were administered individually to each subject. Several criteria aided in the selection of tests for this special battery. The first was that the test must be one which has been used to measure clerical ability. Secondly, the test must measure a relatively simple ability which can be described. The third criterion was the plausibility of the test being related to the clerical test. Only tests were selected which seemed to have a possibility of being related to the clerical test and of measuring a simple ability having value in the analysis of clerical aptitude. A fourth requirement, that of the reliability of the special tests, was considered. When reliability coefficients for similar tests were reported in the literature, such reliabilities were used to lengthen and predict the reliabilities of the tests. If coefficients were not reported for similar tests, reliabilities were determined in a preliminary experiment.

(b) *Special Tests*

Feature Discrimination: (8)

Four tests of feature discrimination were selected from the Michigan Non-Verbal Series prepared by Edward B. Greene. These discrimination tests are designed to measure the ability to observe and compare by having the subject find the unique feature in each row of small faces. The tests consist of four parts: 2A, 3A, 4A, and 5A, with increasing complexity. In the first part, two faces are to be compared; in the second, three; and in the third and fourth parts, five and seven faces are to be compared in each row, respectively. These tests were included in the special battery since observation and comparison, which are the abilities supposedly measured by the feature discrimination tests, are also traits which may have a significant relationship to success in the clerical checking tests.

Number Cancellation:

The number cancellation test consists of two parts of equal length each with a time limit of one and one-quarter min-

utes. There are a total of 1500 numbers in the two parts or 750 in each half. The test is constructed so that there are four sevens to be cancelled in each line, giving a total of 100 sevens to be cancelled in each half. This test is based on the Woodworth-Wells tests of cancellation. Tests of cancellation are assumed to measure quickness in perception, speed of discrimination, and quickness of reaction. Cancellation tests, both number and letter, have been used in various studies of clerical ability. Since speed in perception and discrimination seem to be factors in clerical ability independent of academic ability (9) and seem to be measuring an ability lacking complexity, both letter and number cancellation were included in this study.

Letter Cancellation:

The letter cancellation test was constructed similarly to the number cancellation test. There were two parts, each half made up of 750 letters, among which were 100 a's, four in each line, to be cancelled.

Substitution Tests:

Two tests of substitution are included in the test battery, one of letter substitution and the other of number substitution. Each test is made up of 180 letters or numbers. The letters and numbers are repeated an equal number of times. In the letter substitution test, five letters are to be substituted for five letters and in the number test, five numbers are to be substituted for five numbers. Substitution tests have been called tests of quickness in learning. Most substitution tests, however, seem too simple and brief to be adequate measures of the complicated learning process, but at least they may give an indication of the subject's ability to adapt to a situation in which speed in learning a short code is an advantage. Substitution tests were included in this test battery for several reasons, one being that they have been used by many investigators in the study of clerical ability. (1) (15) (14) (10) (9). Other reasons for including measures of substitution were that such tests seemed to measure the ability to adapt quickly to a new situation, an ability which might be important in clerical tasks.

Verifying Arithmetic Test:

The verifying arithmetic test was designed to measure simple arithmetical ability. The short test consists of 40 prob-

lems in addition, multiplication, subtraction, and division. There are ten problems in each of the above mentioned four categories. All problems are simple enough so that they can be checked mentally. Since the problems are answered, the task of the subject is to place either a C on the line after each problem if the problem is correct, or to place a check on the same line if the answer is wrong. This method is preferred to the writing of the answer since maximum time is spent in calculating and not in writing. Eleven of the forty problems are wrong, some of which are in each of the four kinds of problems. An arithmetic test was included in this series of tests since the relationship between arithmetic and score in a clerical number checking test seems to be an important consideration. Many investigators have included arithmetic tests in their clerical battery. (10) (11) (4) (15).

Spelling Tests:

Two spelling tests also were given to the subjects. The first spelling test, which will be designated as Spelling I, was designed not so much to measure spelling as to measure the ability to perceive quickly and accurately slight misspellings in a group of easy words. These words were chosen from Ayres Spelling Scale and from the word lists which were passed by from 66 per cent of second grade to 58 per cent of fifth grade children. Words selected for the final list are so simple that errors made by an average adult should be made through inaccuracies in perception. The list of fifty words included twenty-six spelled incorrectly and twenty-four spelled correctly. The subject recorded his answer by checking under the column headed 'R' if the item was correct and under 'W' if the word was spelled incorrectly.

The second spelling test, called Spelling II, was definitely designed to measure spelling ability. It includes 175 words selected from the Sixteen Spelling Scales reported in the Teachers' College Series. The words were chosen from word lists which were passed by better than 50 per cent in eighth grade and others were passed by less than 50 per cent in ninth grade. About 56 per cent of the words are spelled incorrectly in the test which means that 99 are wrong and 76 are spelled correctly. The directions for taking the test are the same as those in the easier spelling test. It is apparent from the wide use of spelling tests in

the study of clerical ability (15) (3) (12) that the inclusion of such tests in the analysis of clerical ability is desirable.

Number Group Checking:

The number group checking test has been used extensively in the study of clerical ability. Primarily, it measures the ability to perceive quickly and accurately the presence or absence of two numbers in a group of numbers. In this test 200 groups of numbers are arranged in five columns. The subjects are to check each group that contains both a six and a nine. There are 75 such groups to be checked, fifteen in each column. This test is based on the Woodworth-Wells Number Group Checking Test which contains 168 items, seventy of which are to be checked because they include both a 'one' and a 'seven.' The number group checking test was included in the present investigation because it measures an ability which is apparently closely related to clerical number checking. Number Group Checking Tests have been used by investigators (10) (14) in the measurement of clerical ability.

Test in Adding:

This test requires the ability to follow a line of numbers and to underline any two consecutive numbers whose sum equals ten. The test consists of 1260 numbers which are divided into 20 lines with double spacing between every five lines. In each line there are ten adjacent numbers whose sum equals ten with the exception of three lines in which there are eleven such pairs. Burt (5) believes that such a test is valuable in the prognosis of clerical ability since it demands, like clerical work, a high degree of concentration. Since the Minnesota Clerical Test, as well as other tests, require concentration, the relationship between this adding test and the other clerical tests is worth considering.

TESTING PROCEDURE

The order in which the Institute Battery was given varied with different subjects. The special battery of tests, however, always was given in a definite order and always followed the administration of the clerical test. This rule was adhered to so that no practice effect on the special battery could influence

clerical test scores. The first four tests in the special battery, the four feature discrimination tests, were given in order of increasing difficulty, 2A, 3A, 4A, and 5A. These tests were given first so that the subject would be alert and patient in the task of looking for the one difference in the rather large groups. Number and letter cancellation tests and letter and number substitution tests followed the discrimination tests in the above order. Ninth in the series was the verifying arithmetic test, which was followed by Spelling I and II, and these by number group checking and adding. To serve as a shock absorber, the easier spelling test was given before the more difficult one. The adding test was administered last since it was rather tiring to the eyes. The plan used in determining the above testing order was that tests which are similar should be given consecutively. All tests in the special battery were given by the time limit method.

EVALUATION OF THE TESTS

In a study of the value of any measuring instrument, records of the average score, variability, skewness of the distribution and reliability are important considerations. Table I gives the averages, variabilities, and skewness of the distribution for the variables.

The negative skewness for clerical experience is greater than 3.00 and, therefore, is statistically significant. It indicates that there is a considerable piling up of cases in the intervals of little clerical experience. Since the experimental group has been selected from among young clerical workers, it might be expected that most of the clerical workers would have had little experience. The average worker in this group has had four years' experience in clerical work; about one-sixth of the group have had nine or more years; whereas, about one-third have had less than two years' clerical experience.

The distribution for age is not significantly skewed. The average age for this group of women clerical workers is 23 years and the age range is from 17 to 29 years inclusive.

TABLE I
*Skewness, Means, and Standard Deviations for the Test Scores
 and Other Variables*

MEASURE	MEAN	STAND- ARD DE- VIATION	SK.	σ SK.	$\frac{SK.}{\sigma SK.}$
Years of clerical experience	4.38	3.59	-1.51	.47	-3.23
Age	22.86	3.33	-.63	.43	-1.46
Years of formal schooling	11.99	1.38	.12	.06	2.00
Pressey education tests (average of the two)	69.30	14.01	2.94	1.73	1.70
Clerical: number checking	145.68	28.11	.68	3.68	.19
Clerical: name checking	149.80	28.51	5.62	3.79	1.49
Finger dexterity	3.85	.50	.14	.05	2.50
Tweezer dexterity	5.54	.83	.16	.09	1.78
Manual dexterity	227.71	20.19	-5.44	2.43	-2.24
Spatial relations	1179.24	260.52	64.25	27.88	2.30
Feature discrimination 2A	32.73	8.71	-.88	.99	-.09
Feature discrimination 3A	27.30	6.33	-.06	.67	-.09
Feature discrimination 4A	11.40	5.03	-.16	.63	-.25
Feature discrimination 5A	12.70	4.27	.15	.55	.27
Number cancellation	145.99	27.43	1.40	3.54	.40
Letter cancellation	148.06	28.35	-1.53	3.68	-.42
Letter substitution	115.48	26.76	-8.42	3.55	-2.37
Number substitution	139.61	23.08	-4.38	2.99	-1.47
Verifying arithmetic	25.95	7.54	-2.32	.99	-2.34
Spelling I	44.74	7.65	8.43	.83	10.11
Spelling II	91.55	35.08	6.91	4.29	1.61
Number group checking	144.84	31.17	-.31	4.03	-.08
Adding	101.68	28.48	2.10	3.54	.59

The average clerical worker in this group has had a twelfth grade education, but the range in education is from eighth grade through college graduation. The slight positive skewness indicates that there is a tendency for the piling up to be in the higher educational levels. In academic ability, the average worker in this group has a "B" rating² which is better than 75 per cent of women workers in the general population. There is a tendency for the greatest frequency of cases to be among the better scores in the Pressey Tests.

The mean in clerical number checking for this group of subjects is "B" grade, or a score equal to a percentile of 85 in com-

² General population norm letter grade limits are: Standard score 6.5 and above, A; 5.5 to 6.4, B; 4.5 to 5.4, C; 3.5 to 4.4, D; and 3.4 and below, E.

parison with women workers in general. Distributions for both the clerical number and name checking tests are normal. The average clerical worker in this group exceeds 85 per cent of women workers in the general population in clerical name checking, which is also equal to "B" grade ability.

The distribution for finger dexterity tends to be positively but not significantly skewed. For this group the mean is equal to a percentile of 65 or to "C" grade ability for workers in general. Likewise in tweezer dexterity, the average clerical worker in this group has a percentile rating of 60 or "C" grade for women workers in the general population. In manual dexterity, the average score is equal to the fiftieth percentile or "C" grade ability.

In the spatial relations test, the average for this group of women is also equal to "C" grade or the 65 percentile for women workers in general. The distribution tends to be skewed but not significantly so toward the higher end of the scale.

In concluding the discussion of the scores, for this group, on the Institute Battery of Tests, it is important to note that the average scores resemble closely those for employed women clerical workers tested in an earlier study. (2).

The range of scores on the feature discrimination tests was large, extending from near zero to maximum scores. All distributions are approximately normal.

On the cancellation tests, the average scores are about equal for number and letter cancelling. The number substitution test, however, has a higher average score than has letter substitution. Part of this gain may exist because a number code is more easily learned or because in the second part the subject is more adapted to substitution. The curves for cancellation are not skewed, whereas the distributions for the substitution tests are slightly but not significantly skewed, indicating a piling up in the lower scores.

The average clerical worker in this group scores 26 out of a possible 40 in the Verifying Arithmetic Test. The skewness

which is present is not significant but it does indicate that the scores tend to be at the lower end of the scale.

Because of the high average score, 48 out of 50, and the extreme positive skewness of the distribution, the Spelling I Test is not deemed satisfactory as a differentiating instrument for this group of clerical workers. In a preliminary study, the average score for a group of workers chosen at random was 24.5 on this Spelling Test. For a group of clerical workers, however, the test is too easy. Although the Spelling I Test is used in the intercorrelations, it is eliminated in the later calculations because of its skewed distribution of scores. In the Spelling II Test the average score is 92 out of a possible 175 and the distribution of scores is not significantly skewed.

Both the number group checking and the adding tests give normal distributions for this group of women workers. The average score in number group checking is 145 out of a possible 200 and, in adding, a score of 102 out of a possible 200.

Because of incompleteness of data the manual dexterity test could not be used in the factor analysis study. Manual dexterity, however, correlates +.36 with clerical number checking and +.29 with clerical name checking.

RELIABILITY OF THE TESTS

In studying interrelationships of abilities, the measuring instruments should have a high degree of internal consistency. Table II gives reliability coefficients for the tests used in this study.

The reliability of the Pressey Education Tests is sufficiently high for individual diagnosis. Calculated by comparing scores on the Senior Classification with scores on the Senior Verification Tests, the reliability was +.90 for women workers and +.91 for men workers. (13). In this study the average of the scores on the two tests was used, so we may expect the reliability for this group to be equally high.

The reliability of the finger dexterity test for a heterogeneous group of women workers is +.81, corrected, +.90. For

a homogeneous group of 200 clerical workers, 155 of which are included in this study, the reliability is $+ .74$ or corrected, $+ .85$. This slight decrease in reliability was expected because of the homogeneity of the group.

Reliabilities could not be directly ascertained for the tweezer dexterity test from the Institute data, since the one trial given yielded only one time score. Indirect evidence of its reliability is gained from a study of the relationship of the finger to the tweezer dexterity test. (13). For three random subgroups of women, the average intercorrelation is $+ .33$. The average intercorrelation for the total sample is $+ .32$. Difference ratios for the three groups are not significant. Darley (13) concluded that the "consistency with which this relationship is maintained again suggests but does not prove that the Tweezer Dexterity Test approximates in reliability the Finger Dexterity Test." Study of the scores of men workers indicate similar results.

The manual dexterity test has a reliability of $+ .84$, or corrected, $+ .91$ when the first and third trials are compared with the second and fourth trials for a group of 150 women workers. The reliability of the Spatial Relations Test is $+ .80$ or corrected, $+ .89$ when boards A and B are compared with boards C and D for 224 women workers.

The reliability of the Minnesota Clerical Test has been tested many times by various procedures, and with various groups. Both odd-even and test-retest reliability coefficients for various groups have indicated that the reliability of the test is sufficiently high for individual diagnosis. The reliabilities of $+ .86$ and $+ .93$, uncorrected, reported in Table II for women clerical workers are additional evidence for the reliability of the clerical number and name checking tests.

Darley concluded with respect to the Institute Battery of Tests that "the aptitude and ability tests used by the Research Institute meet the criterion of reliability for use in making group comparisons, and with the exception of the mechanical assembly boxes each test seems to be adequate for individual diagnosis." (13).

TABLE II
Reliabilities of Tests Used in This Study

TESTS	DESCRIPTION OF GROUP	ODD-EVEN		SPEARMAN- BROWN
Pressey Tests* (Classification vs. Verification)	131 women workers	.90	.02	
		(Comparable Forms)		
Finger dexterity* (first 50 vs. 2nd 50 holes)	215 women workers	.81	.02	.90
Finger dexterity	200 women clerical workers	.74	.02	.85
Tweezer dexterity*	See explanation			
Manual dexterity*	150 women workers	.84	.02	.91
Spatial relations*	224 women workers	.80	.02	.89
Clerical number checking	147 women clerical workers	.86	.01	.92
Clerical name checking	147 " " "	.93	.01	.97
Feature discrimination 2A	200 " " "	.95	.004	.97
Feature discrimination 3A	200 " " "	.94	.01	.97
Feature discrimination 4A	200 " " "	.94	.01	.97
Feature discrimination 5A	200 " " "	.88	.01	.94
Number cancellation	200 " " "	.70	.03	.82
Letter cancellation	200 " " "	.81	.02	.89
Letter substitution	200 " " "	.98	.001	.99
Number substitution	200 " " "	.99	.001	.99
Verifying arithmetic	200 " " "	.93	.01	.96
Spelling I	200 " " "	.89	.01	.94
Spelling II	200 " " "	.92	.01	.96
Number group checking	200 " " "	.86	.01	.92
Adding	200 " " "	.98	.002	.99

* Reliabilities for the academic ability, finger, tweezer, manual dexterity, and spatial relations tests (starred) are taken from "Research Studies in Individual Diagnosis," Editor, Donald G. Paterson, Bulletin of the Employment Stabilization Research Institute, pp. 44 and 46.

All tests in the special battery are sufficiently reliable for individual prediction with the possible exception of the number cancellation test which is reliable enough for group prediction.

THE RELATION BETWEEN TEST SCORES AND AGE, CLERICAL EXPERIENCE, AND FORMAL EDUCATION

Since age has been controlled by eliminating all clerical workers over 29 years of age, a decrement in test scores due to age should not be expected. The only correlations between age and the other variables which border on significance are those between age and Spelling I and age and Adding. Table III shows these correlations.

TABLE III
Relations between Test Scores and Age, Clerical Experience and Education

TEST	AGE	CLERICAL EXPERI- ENCE	EDUCATION
Pressey education tests .. .. .	.105	.145	.416
Finger dexterity .. .. .	.161	.118	-.013
Tweezer dexterity .. .. .	.106	.102	.195
Spatial relations	-.054	-.046	.025
Clerical number checking	.164	.312	.282
Clerical name checking .. .. .	.157	.301	.168
Feature discrimination 2A .. .. .	.109	.154	.092
Feature discrimination 3A .. .. .	.094	.117	.256
Feature discrimination 4A .. .. .	.109	.043	.123
Feature discrimination 5A .. .. .	.010	.081	.264
Number cancellation .. .. .	.158	.050	.336
Letter cancellation .. .. .	.148	.108	.229
Letter substitution .. .. .	.135	.154	-.049
Number substitution .. .. .	.101	.126	.205
Verifying arithmetic .. .. .	.083	.141	.156
Spelling I .. .. .	.237	.251	.368
Spelling II .. .. .	.164	.258	.388
Number group checking .. .. .	.193	.197	.149
Adding .. .. .	.221	.196	.095

Probable error .054—correlation must be .22 to be significant.

The only correlations indicating even a slight relationship between clerical experience and test scores are those for the two clerical checking tests and the two spelling tests. Such relationships do not necessarily mean that those with more clerical experience are in a better position to score high in these tests because of that experience; rather, they mean that those who are successful clerical workers, as evidenced by many years of employment, have better clerical and spelling abilities. The relationships, however, are so slight that little weight can be placed in them.

As might be expected, academic ability is more closely related to years of schooling than to any of the tests. Those with higher academic ability ratings tend to stay in school and complete more grades than those with lower ratings. Two of the feature discrimination tests correlate better than chance with years of schooling. Since these two correlations are not for two consecutive forms, the relationship does not indicate that the more difficult tests are more affected by schooling.

The Arithmetic Test is not related to education since all individuals with an eighth grade education can answer all of the problems. Since this is a group of clerical workers who have had experience with numerical calculations it would be expected that schooling in and of itself would exert little effect.

The two spelling tests are related to schooling; those with more schooling score somewhat higher on the spelling tests. Since schooling is related to academic ability, it is likely that those who spell better are those who not only attended school longer but also have better academic ability and retained better what they learned in these grades. All other relationships in this table are low and possibly are due to chance.

When the relationships between age, clerical experience, and education are considered, the correlations show that clerical experience is not related to years of schooling, $-.015$, but there is a marked relationship between age and clerical experience as indicated by a coefficient of $+.791$. Those who are older have had more clerical experience than those who are younger.

This signifies that the older members of the group are persons who have remained in clerical work and have accepted it as a permanent vocation. There is a negligible relationship between age and years of schooling, the correlation being +.155.

INTERCORRELATIONS AND INTERPRETATIONS OF THE RELATIONSHIPS AMONG THE TESTED ABILITIES

One of the most important considerations in any study of the analysis of mental abilities is the inquiry into the intercorrelations among these abilities. All degrees of relationship are important, from the chance relations indicating the uniqueness of the variable in respect to that ability to the correlations which indicate some or a high degree of relationship.

Table IV gives the coefficients of correlations among the nineteen variables for this group of women clerical workers. The correlations to the right of the diagonal are the uncorrected correlations, and those to the left of the diagonal are the correlations corrected for attenuation. These corrected coefficients can serve only as indications of the possible correction, since the reliabilities upon which the corrections are based, are not all calculated for the same group, a group of women clerical workers.

There are ten correlations in Table IV which are greater than +.50. These most important relationships may be summarized as follows:

Number and letter cancellation	.84	corrected	.98
Spelling I and II	.70	"	.73
Clerical number and name checking	.66	"	.69
Clerical names and spelling II	.65	"	.68
Clerical names and spelling I	.63	"	.66
Number group checking and adding	.60	"	.63
Clerical number checking and spelling I	.53	"	.57
Feature discrimination 4A and 5A	.53	"	.56
Letter and number substitution	.52	"	.52
Clerical number checking and arithmetic	.51	"	.54

The highest correlations indicate what "single factorists" refer to as group factors.

TABLE IV
*Corrected and Uncorrected Intercorrelations for the Nineteen Ability Tests**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1.		.091	.119	.227	.253	.411	.325	.271	.283	.375	.116	.142	.328	.221	.332	.453	.450	.126	.202
2.	.104		.331	.245	.255	.185	.051	.242	.021	.151	.158	.086	.162	.222	.167	.092	.027	.228	.173
3.	.136	.390		.269	.309	.214	.057	.297	.109	.202	.338	.185	.160	.177	.134	.192	.076	.160	.220
4.	.254	.282	.309		.091	.136	.272	.296	.320	.435	.276	.259	.168	.217	.190	.227	.119	.140	.262
5.	.277	.288	.349	.100		.655	.187	.376	.210	.382	.359	.416	.369	.462	.507	.528	.459	.479	.436
6.	.441	.204	.237	.146	.693		.288	.375	.288	.421	.400	.370	.431	.465	.430	.629	.653	.488	.452
7.	.347	.056	.062	.292	.197	.297		.473	.344	.247	.231	.208	.249	.206	.214	.369	.371	.282	.230
8.	.290	.256	.328	.319	.397	.387	.487		.355	.433	.347	.444	.165	.346	.247	.330	.334	.355	.350
9.	.303	.023	.126	.372	.222	.298	.354	.367		.529	.287	.193	.241	.230	.178	.255	.155	.138	.282
10.	.408	.169	.226	.475	.428	.442	.258	.455	.556		.312	.304	.240	.306	.241	.458	.328	.230	.303
11.	.135	.189	.405	.323	.412	.449	.258	.388	.322	.355		.837	.430	.366	.270	.403	.318	.482	.493
12.	.158	.098	.207	.291	.458	.398	.223	.478	.208	.332	.978		.301	.434	.369	.386	.383	.425	.482
13.	.347	.177	.174	.179	.387	.443	.253	.169	.247	.249	.477	.320		.517	.380	.349	.469	.333	.370
14.	.223	.241	.193	.230	.482	.474	.210	.352	.234	.317	.405	.461	.521		.342	.348	.349	.389	.411
15.	.357	.185	.148	.206	.538	.463	.217	.256	.184	.253	.304	.399	.388	.350		.407	.416	.302	.367
16.	.491	.114	.214	.254	.565	.659	.385	.346	.267	.487	.458	.421	.360	.359	.427		.696	.391	.414
17.	.485	.030	.083	.129	.488	.680	.385	.347	.161	.346	.358	.415	.482	.358	.434	.733		.359	.368
18.	.137	.257	.181	.154	.518	.516	.297	.375	.145	.247	.554	.468	.348	.406	.320	.418	.382		.600
19.	.214	.189	.240	.262	.456	.462	.233	.357	.288	.314	.546	.513	.373	.415	.376	.429	.378	.628	

* Uncorrected correlations are to the right of the diagonal and corrected to the left of the diagonal. Corrected correlations were found by applying the correction for attenuation and using Spearman-Brown reliabilities with the exception of the Pressey Test for which the correlation for comparable forms without correction was used.

KEY TO TABLE

- | | | |
|-------------------------------------|-------------------------------|---------------------------|
| 1. Average of the two Pressey Tests | 8. Feature discrimination 3A | 14. Number substitution |
| 2. Finger dexterity | 9. Feature discrimination 4A | 15. Verifying arithmetic |
| 3. Tweezer dexterity | 10. Feature discrimination 5A | 16. Spelling I |
| 4. Spatial relations | 11. Number cancellation | 17. Spelling II |
| 5. Clerical number checking | 12. Letter cancellation | 18. Number group checking |
| 6. Clerical name checking | 13. Letter substitution | 19. Adding |
| 7. Feature discrimination 2A | | |

Academic ability, as measured by the Pressey Tests, is most closely related to the verbal abilities, or to such tests as clerical name checking and spelling. Academic ability is related to clerical abilities and to the feature discrimination tests, but it is relatively independent of the simple dexterities, cancellation, and number group checking.

Finger dexterity is more closely related to tweezer dexterity than to any other test, but this correlation is only $+ .33$. Finger dexterity is more related to tweezer dexterity, spatial and numerical abilities, than to academic or verbal abilities of which it is relatively independent.

Tweezer dexterity is unrelated to academic ability, number and letter substitution, arithmetic, spelling, and number group checking tests. Number cancellation, finger dexterity, and clerical number checking are associated with tweezer dexterity. It is apparent that tweezer dexterity is more closely related than finger dexterity to the clerical tests.

The Minnesota Spatial Relations Test, a measure of mechanical ability, is more closely related to the most complex feature discrimination test than to any other test included in this battery. It is also somewhat related to finger and tweezer dexterity which indicated that the three performance tests are associated. Spatial ability is definitely independent of clerical ability. Table V gives the relationships between the spatial relations test and the other tests in the battery with academic ability held constant.

Clerical number checking, although most highly correlated with clerical name checking, shows definite relations to the other clerical tests. Clerical number checking is more highly related to finger and tweezer dexterity, letter cancellation, and arithmetic than clerical names is correlated with these tests. Partial correlations with academic ability constant indicate that the only test which is more closely connected to clerical number than to name checking is the verifying arithmetic test. The only test which is definitely unrelated to clerical number checking is spatial relations.

TABLE V
Partial Correlations between Other Variables with Academic Ability Constant

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	.331	.051	.242	.021	.151	.158	.086	.162	.222	.167	.092	.027	.228	.173
2.	.322		.057	.297	.109	.202	.338	.185	.160	.177	.134	.192	.076	.160
3.	.022	.019		.473	.344	.247	.231	.208	.249	.206	.214	.369	.371	.282
4.	.226	.277	.423		.355	.433	.347	.444	.165	.346	.247	.330	.334	.355
5.	-.005	.078	.278	.301		.529	.287	.193	.241	.230	.178	.255	.155	.138
6.	.122	.171	.142	.369	.476		.312	.304	.240	.306	.241	.458	.328	.230
7.	.148	.328	.205	.330	.266	.290		.837	.430	.366	.270	.403	.318	.482
8.	.074	.174	.173	.427	.161	.272	.836		.301	.434	.369	.386	.383	.425
9.	.140	.129	.159	.083	.163	.133	.418	.272		.517	.380	.349	.469	.333
10.	.213	.156	.145	.304	.178	.245	.351	.417	.482		.342	.348	.349	.389
11.	.146	.100	.118	.172	.093	.132	.246	.344	.304	.292		.407	.416	.302
12.	.057	.171	.263	.240	.148	.347	.394	.364	.237	.284	.304		.696	.391
13.	-.016	.025	.267	.246	.033	.191	.299	.361	.331	.287	.317	.617		.359
14.	.219	.151	.257	.336	.107	.198	.474	.414	.311	.372	.278	.340		.600
15.	.158	.201	.177	.312	.238	.458	.484	.468	.323	.383	.324	.368	.352	.592

Correlations to the right of the diagonal are uncorrected intercorrelations; those to the left of the diagonal are the partial correlations, with academic ability constant.

1. Finger dexterity
2. Tweezer dexterity
3. Feature discrimination 2A
4. Feature discrimination 3A
5. Feature discrimination 4A
6. Feature discrimination 5A
7. Number cancellation
8. Letter cancellation

9. Letter substitution
10. Number substitution
11. Verifying arithmetic
12. Spelling I
13. Spelling II
14. Number group checking
15. Adding

Clerical number checking and the two spelling tests are definitely related to clerical name checking. With academic ability held constant, clerical name checking is more closely correlated with feature discrimination 2A and 4A and the two spelling tests than is clerical number checking. The other clerical tests show some degree of relationship to name checking, although academic ability is somewhat more closely related to name than to number checking. Clerical name checking is relatively independent of finger dexterity and spatial relations. Even after academic ability is held constant, there is a relationship of .58 between clerical name checking and spelling II.

Feature discrimination 2A, the simplest among the discrimination tests, is more closely related to feature discrimination 3A than to any other test. It is also correlated with academic ability and the spelling tests, which correlations show a considerable decrease when academic ability is held constant. Finger and tweezer dexterity, letter substitution, and clerical number checking are definitely unrelated to this test of observation and comparison.

Feature discrimination 3A like the other tests of observation and comparison is more closely related to other feature discrimination tests, in this case 2A and 5A, than to any other tests. All of the clerical series are correlated positively with feature discrimination 3A with the exception of letter substitution which is relatively independent of this test.

Feature discrimination 4A is most closely associated with other discrimination tests and spatial relations. The only test with which 4A is more closely connected than 5A is feature discrimination 2A. Finger and tweezer dexterity, clerical number checking, letter cancellation, arithmetic, spelling II, and number group checking show little indication of being related to the 4A discrimination test.

Feature discrimination 5A is more closely related than feature discrimination 4A to the clerical and spatial abilities. This test, the most complex in the discrimination series, is more closely related to spatial and to the other feature discrimina-

tion tests than is clerical name checking. It is also more closely associated than spatial relations to most of the clerical tests and to academic ability. Finger and tweezer dexterity are the only tests in this battery which are relatively independent of this test in feature discrimination.

Feature discrimination tests 3A and 5A are closely related to the clerical tests; 4A and 5A are closely associated with spatial ability, and 2A and 5A with academic ability. These tests, designed to measure the ability to observe and compare differences, measure not only academic ability, as stated by Greene, but abilities which are important in the clerical and spatial tests. Although all four discrimination tests are similar excepting for their complexity, the relationship between any two of them is not as high as those between two spelling, clerical checking, or cancellation tests. Each form measures an ability somewhat different from the preceding.

The two cancellation tests are very closely related as shown by the correlation of $+ .84$, or corrected $+ .98$. The clerical tests particularly number group checking, adding, substitution, and clerical name and number checking tests are related to the cancellation tests. Two tests which are definitely unrelated to cancellation are finger dexterity and academic ability. The type of motor ability required in tweezer dexterity is more closely related than finger dexterity to speed in cancellation.

The two substitution tests are more closely related to each other than to any other test, as is evidenced by the intercorrelation of $+ .52$. Both tests are associated significantly with clerical and academic ability. Letter substitution is relatively independent of finger and tweezer dexterity, spatial relations, and 3A of the discrimination tests. Number substitution is unrelated to tweezer dexterity.

Arithmetical ability, as measured by the Verifying Arithmetic test, is more closely dependent upon clerical number checking than upon any other test. This relationship is little affected by the presence of academic ability in the correlation while other relationships between arithmetic and clerical name

checking or the spelling tests are greatly decreased when academic ability is held constant. The only tests which are definitely unrelated to arithmetic are finger and tweezer dexterity, spatial relations, and feature discrimination 4A.

The two spelling tests are more closely associated with each other than with any other test. They are, however, very closely related to clerical name checking. The higher correlations between spelling and clerical name checking cannot be explained by a common factor of speed since all of the tests in the battery are time tests. To test the importance of speed in such a relationship, 77 vocational high school students were given the clerical test and a 50 word spelling test. Speed was not a factor in the spelling test, since all words were pronounced singly and enough time was allowed for each student to write each word. The correlation between this test in commercial spelling and clerical number checking is $+ .22$, while the relationship between spelling and clerical name checking is $+ .55$.

Clerical name checking is more highly correlated with other clerical tests than are the spelling tests. The spelling tests are significantly related to clerical and academic abilities. Spelling I is independent of finger dexterity and feature discrimination 2A. Finger and tweezer dexterity, spatial relations, and 4A are unrelated to the more complex spelling test.

Number group checking and adding are rather highly correlated, as shown by the correlation of $+ .60$ or of $+ .59$ with academic ability held constant. Number group checking is related to all the clerical tests and is independent of academic ability, tweezer dexterity, spatial relations, and feature discrimination 4A. Number group checking, then, is measuring a clerical factor which is free from the influence of academic, dexterity, and spatial factors.

Although number group checking and adding are associated, the adding test shows more relationship to academic ability, tweezer dexterity, spatial relations, the more complex discrimination tests, and arithmetic tests than does number group

checking. Adding is related to the clerical tests, academic, and spatial abilities, but is independent of finger dexterity.

From the discussion of the intercorrelations, it is evident that there are several factors operating, among which seem to be academic ability, clerical aptitude, spatial ability, and possibly a dexterity factor. There is the additional probability that clerical ability may include a numerical and a verbal factor. Factor loadings and tetrad analysis will be required to provide an analysis of these abilities.

The above conclusions have been drawn from an analysis of each test when considered alone. Table VI shows some of the relationships which are present when the tests are grouped according to the following plan :

Dexterity : Finger and Tweezer.

Feature discrimination : 2A, 3A, 4A, 5A.

Verbal ability : Clerical : Clerical name checking, letter cancellation, letter substitution, and spelling II.

Numerical ability : Clerical : Clerical number checking, number cancellation, number substitution, arithmetic, number group checking, and addition.

The average intercorrelation for all of the variables of +.27 indicates the tendency for all desirable traits to be positively correlated. Clerical experience and education are independent of all the test groups. Academic ability is related to the feature discrimination and verbal (clerical) tests, but is relatively independent of dexterity and numerical (clerical) tests. The feature discrimination tests are most closely related to spatial ability, then academic, clerical-verbal, and numerical abilities. Dexterity is not related to academic, verbal-clerical, numerical-clerical or feature discrimination tests. Dexterity is slightly related to spatial ability. Verbal-clerical and numerical-clerical abilities are independent of spatial ability, but spatial ability is somewhat related to dexterity, academic, and feature discrimination abilities.

There is little evidence for the isolation of a verbal and numerical factor from the intercorrelations for these test

TABLE VI
Average Correlations between Various Groups of Tests

	r
Clerical experience and feature discrimination ..	.099
Clerical experience and dexterity .. .. .	.110
Clerical experience and verbal (clerical) .	.156
Clerical experience and numerical (clerical) .	.138
Education and feature discrimination .....	.184
Education and dexterity .. .. .	.091
Education and verbal (clerical) .. .. .	.191
Education and numerical (clerical) .. .	.155
Academic ability and feature discrimination ...	.314
Academic ability and dexterity ..	.105
Academic ability and verbal (clerical) .....	.333
Academic ability and numerical (clerical) ....	.208
Feature discrimination and dexterity .. .. .	.141
Feature discrimination and verbal (clerical) .....	.288
Feature discrimination and numerical (clerical)	.269
Feature discrimination and spatial .	.331
Dexterity and spatial .. .. .	.257
Dexterity and verbal (clerical) .. .. .	.137
Dexterity and numerical (clerical) .. .. .	.212
Spatial and verbal (clerical) .. .. .	.171
Spatial and numerical (clerical) .. .. .	.196
Clerical verbal and numerical .. .. .	.438
Clerical verbal and verbal .. .. .	.435
Clerical numerical and numerical .. .. .	.418

groups. The verbal tests correlated with the verbal tests no more highly than did the verbal tests with the numerical group. The numerical tests were also no more closely related to the numerical tests than they were to the verbal tests. These intercorrelations in the +40's indicate a fair degree of relationship between the various clerical tests, whether they be of a verbal or of a numerical content.

Although the tests when grouped show no evidence for a verbal and numerical factor, two of the tests, those of arithmetic and spelling ability, which unlike the other tests, truly represent numerical and verbal content, do give some indications of the differentiation of numerical from verbal facility.

SUMMARY AND CONCLUSIONS

The purpose of this study was to make a comprehensive analysis of the Minnesota Vocational Test for Clerical Workers. Earlier results have indicated that the Minnesota Test is a reliable and valid measure of clerical aptitude, and is relatively free from the influence of clerical training and experience. Both the clerical number and name checking tests are relatively independent of academic ability when homogeneous groups are considered. For more heterogeneous groups, only clerical number checking is independent of academic ability. The clerical test differentiates clerical workers from workers in the general population and from workers in various non-clerical occupations.

The four problems which have been singled out for study are:

(1) to discover what aptitudes the clerical test is measuring and what traits are closely related to it.

(2) to determine whether the clerical test is measuring a unique trait which is relatively independent of other tested abilities.

(3) to determine the value of multiple factor and tetrad analysis techniques in the study of the overlapping among abilities and of the number of factors involved in a test battery which measures academic, clerical, dexterity, and mechanical abilities.*

(4) to evaluate the contributions and the limitations of factor analysis techniques, in a vocational testing program.*

An attempt has been made in this study to meet the usual criticisms made against studies in mental analysis and the interrelationships among abilities. A group of young women clerical workers, homogeneous as to sex, age, and general occupation has served as the experimental group. The tests were used only after they had shown themselves to be reliable measuring instruments and capable of giving a normal distribution of scores.

* The last two problems will be discussed in a subsequent article in this journal.

To study the first problem, namely, that of the nature of the test and the abilities to which it is related, tests were selected which supposedly measured relatively simple clerical abilities and were revised to meet the requirements of reliability. These tests include number and letter cancellation, letter and number substitution, arithmetic, spelling, number group checking, and addition. Four feature discrimination tests from the Michigan Non-Verbal Series devised by E. B. Greene were also used because they supposedly measured an ability to observe and compare an ability which might be closely related to the clerical test.

The uniqueness of the clerical test was studied by observing its relation to the Pressey Education Tests, the O'Connor Finger and Tweezer Dexterity Tests, and the Minnesota Spatial Relations Test, which tests were used by the Minnesota Employment Stabilization Research Institute in its testing program.

RESULTS

All of the tests with the exception of number cancellation, have reliabilities of at least $+ .85$ which are sufficiently high for purposes of individual diagnosis. The number cancellation test is reliable enough to determine group differences.

The average intercorrelation for all of the variables is $+ .27$ which indicates the tendency for desirable traits to be positively correlated. The uncorrected correlations range from $.00$ to $+ .84$; the highest correlation is between number and letter cancellation.

Correlational analysis seems to indicate that this test battery is measuring at least four relatively independent factors, those of academic, clerical, spatial, and dexterity abilities. There is also the possibility that the clerical number and name checking tests are measuring two factors, one a numerical ability, and the other a verbal ability. There are also indications that the two dexterity tests, though related, are measuring relatively specific abilities. The feature discrimination tests seem

to be measuring abilities which are important in academic, clerical, and spatial relations tests. Although spatial relations is more closely related to finger and tweezer dexterities than are the feature discrimination tests, the feature tests are more closely associated than spatial relations to clerical and academic abilities. When the feature discrimination tests are considered in one group the verbal-clerical tests separated from the numerical-clerical tests and the two dexterity tests combined, the relationships give a composite picture of the many correlations.

The correlations indicate that both clerical experience and education are independent of the abilities measured by these various test groups. Academic ability is significantly related to the verbal-clerical and feature discrimination tests but is independent of the numerical-clerical tests and dexterities. The feature discrimination tests are related to the spatial and clerical tests, but are independent of the dexterity tests. The dexterity tests are somewhat related to spatial ability but are independent of other test groups. Spatial ability is definitely unrelated to the clerical test groups, those dealing with letters and those dealing with numbers, no differences are present between the correlations of the verbal with the verbal and the verbal with the numerical tests. Although the arithmetic, spelling, and clerical number and name checking indicate some differences between the verbal and numerical abilities, other tests of substitution, cancellation, number group checking, and addition do not indicate such differences.

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