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FUNDAMENTAL FACTORS OF COMPREHENSION IN READING

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A survey of the literature was made to determine the skills involved in reading comprehension that are deemed most important by authorities. Multiple-choice test items were constructed to measure each of nine skills thus identified as basic. The intercorrelations of the nine skill scores were factored, each skill being weighted in the initial matrix roughly in proportion to its importance in reading comprehension, as judged by authorities. The principal components were rather readily interpretable in terms of the initial variables. Individual scores in components I and II are sufficiently reliable to warrant their use for practical purposes, and useful measures of other components could be provided by constructing the required number of additional items. The results also indicate need for workbooks to aid in improving students' use of basic reading skills. The study provides more detailed information regarding the skills measured by the *Cooperative Reading Comprehension Tests* than has heretofore been provided regarding the skills actually measured by any other widely used reading test. Statistical techniques for estimating the reliability coefficients of individual scores in principal-axes components, for determining whether component variances are greater than would be yielded by chance, and for calculating the significance of the differences between successive component variances are illustrated.

The application of techniques of factorial analysis to the investigation of reading has been attempted several times. Feder (11), Gans (12), and Langsam (23) have published studies that employed Thurstone's centroid method, and unpublished studies have been made by Bedell and Pankaskie. So far as the writer is aware, the study reported here is the first to make use of tests especially constructed to measure the mental skills in reading comprehension that are considered of greatest importance by authorities in the field.**

The most important step in a study that employs factorial procedures for the investigation of reading comprehension is the selection of the tests the scores of which are to be factored. Unless these tests provide reasonably valid measures of the most important mental skills that have to be performed during the process of reading, the application of the most rigorous statistical procedures can not yield meaningful and significant results. The importance of this point can hardly be overstated.

* On leave for military service.
** For a detailed presentation of the basic data of this study, see (8).

As the first step in the present study, a careful survey was made of the literature to identify the comprehension skills that are deemed most important by authorities in the field of reading. A list of several hundred specific skills was compiled, many of them overlapping. This list of skills was studied intensively by the writer in order to group together those that seemed to require the exercise of the same, or closely related, mental skills. The objective was to obtain several groups of skills, each one of which would constitute a cluster having relatively high intercorrelations and relatively low correlations with other clusters of skills.

Nine groups of skills were sorted out and labeled. For the purposes of this study, they are regarded as the nine skills basic to comprehension in reading. Included within them is the multitude of specific skills considered important by the authorities consulted. These nine basic skills are as follows:

1 Knowledge of word meanings
2 Ability to select the appropriate meaning for a word or phrase in the light of its particular contextual setting
3 Ability to follow the organization of a passage and to identify antecedents and references in it
4 Ability to select the main thought of a passage
5 Ability to answer questions that are specifically answered in a passage
6 Ability to answer questions that are answered in a passage but not in the words in which the question is asked
7 Ability to draw inferences from a passage about its contents
8 Ability to recognize the literary devices used in a passage and to determine its tone and mood
9 Ability to determine a writer's purpose, intent, and point of view, i.e., to draw inferences about a writer

To provide a measure of each one of these nine basic skills, a large number of five-choice objective test items were constructed. All possible care was taken to obtain items that measured only one rather than several of the nine skills. However, it was recognized that skill 1 (knowledge of word meanings) is basic to the measurement of all the other skills, since to read at all one has to recognize words and understand their meanings, and that some overlapping of skills 2-9 is inevitable.

Since the final forms of the reading-comprehension tests used in this study were to be the published forms of Tests C1 and C2 of Form Q of the *Cooperative Reading Comprehension Tests*, practical considerations [notably the requirements of the procedure for obtaining

three equivalent "scales" in the tests (6)] determined in some measure the number of items testing each basic skill that could be used. An effort was made, however, to include the proportion of items testing each one of skills 2-9 that conformed to the judgments of authorities in the field of reading.

To obtain the intercorrelations of scores in the nine basic reading skills selected for measurement, 240 multiple-choice items were administered to a large number of freshmen in several teachers colleges.* The students were told to mark every item and were allowed an unlimited amount of time. By this means, the influence of speed of reading was removed and the effects of mechanical difficulties in word perception were minimized. Of the 541 students tested, 421 actually answered every item, and, when proof was obtained that this group constituted a representative sample of the entire 541 students tested, the scores of only these 421 pupils were used in the factorial analysis. In addition to the intercorrelations of the scores, the correlations between sex and scores in each of the nine skills were computed. As would have been expected, the correlations with sex were all insignificantly different from zero. This being so, there was no need to partial out the influence of sex before making a factorial analysis.

Table 1 shows the intercorrelations of the scores in the nine basic reading skills, and their relationships with sex.

TABLE 1

Intercorrelations, Means, and Standard Deviations of Raw Scores in the Nine Basic Reading Skills, and Their Relationships with Sex ($N = 421$)

Skill	1	2	3	4	5	6	7	8	9	Sex*	Mean	σ
1		.72	.41	.28	.52	.71	.68	.51	.68	.03	23.77	11.61
2			.34	.36	.53	.71	.68	.52	.68	−.07	12.70	3.25
3				.16	.34	.43	.42	.28	.41	−.01	4.20	1.73
4					.30	.36	.35	.29	.36	−.03	2.97	1.10
5						.64	.55	.45	.55	−.04	18.10	2.46
6							.76	.57	.76	−.01	25.67	5.67
7								.59	.68	.06	28.46	5.81
8									.58	−.05	6.75	1.86
9										−.05	15.19	4.07

* A positive coefficient in this column indicates that the men obtained a higher mean score than the women.

* Every freshman in all of the teachers colleges of the State of Connecticut and every freshman in two of the Massachusetts State Teachers Colleges comprised the sample tested. The testing was done about a month after the beginning of the school year.

The intercorrelations of the nine basic skills range from .16 to .76, the values reflecting in part their true relationships and in part the differences in their reliability. The reliability coefficients of the scores in the nine skills are shown in Table 2.

TABLE 2

Reliability Coefficients of Raw Scores in Each of the Nine Basic Reading Skills*

Skill	r_{11}	N	Number of Items
1	.90	100	60
2	.56	100	20
3	.44	100	9
4	.18	421	5
5	.55	100	22
6	.77	100	42
7	.63	100	43
8	.64	100	10
9	.71	100	27

* The division of each test into two halves was accomplished in this case by arranging the items in order of difficulty and assigning alternate items to each half. It will be recalled that speed had no influence on these scores. The reliability coefficient for skill 4 is based on 421 cases; the reliability coefficients for the other skills are based on a representative sample of 100 cases drawn from the 421 available.

As would be expected in view of the widely different lengths of the tests used to measure the nine basic reading skills, their reliability coefficients differ considerably. For even the least reliable, however, the reliability coefficient is substantially and significantly greater than zero.

Subjective judgment had forecast relatively high correlations between skill 1 and each of skills 2-9. Inspection of Table 1 in the light of the data in Table 2 reveals this to be so. It is apparent that skill 1 constitutes the largest element common to all of the other initial variables; hence, it may be of interest to study the intercorrelations of skills 2-9 when skill 1 is held constant. These partial coefficients are shown in Table 3.

TABLE 3

Partial Correlation Coefficients Among Skills 2-9, Skill 1 Being Held Constant ($N = 421$)

Skill	3	4	5	6	7	8	9
2	.09	.23	.26	.40	.38	.26	.37
3		.05	.16	.22	.22	.09	.20
4			.19	.23	.22	.17	.24
5				.45	.32	.26	.32
6					.53	.33	.53
7						.38	.40
8							.38

Perhaps the most surprising feature of the data in Table 3 is the small size of the coefficients. After making due allowance for the attenuation resulting from the comparatively low reliability coefficients of some of the variables, it is apparent that reading comprehension, as measured by the nine basic reading skills, is not a unitary ability. From the correlations it appears probable that a mental ability present to the greatest extent in skills 6, 7, and 9 is second most important in producing the intercorrelations shown in Table 1. To explore this matter, a factorial analysis was undertaken, using the method described by T. L. Kelley (22).*

The initial matrix of variances and covariances used in the factorial analysis is presented in Table 4.

TABLE 4

Initial Matrix of Variances and Covariances*

Variable	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
x_1	134.70	27.01	8.16	3.65	14.77	46.88	45.78	11.04	32.07
x_2		10.56	1.94	1.29	4.22	13.03	12.90	3.17	8.93
x_3			3.01	0.31	1.44	4.24	4.24	0.90	2.91
x_4				1.22	0.82	2.25	2.25	0.59	1.63
x_5					6.05	8.93	7.85	2.07	5.53
x_6						32.17	24.89	5.96	17.42
x_7							33.75	6.33	16.00
x_8								3.46	4.42
x_9									16.54

* Variances are shown in the diagonal cells. The Kelley method would be equally applicable if the scores in variables 1-9 were transformed into standard measures. In this case, the variance in each diagonal cell would be 1 and the covariances would be identical with the intercorrelations shown in Table 1. The resulting matrix would undoubtedly present a more familiar appearance to many students. Each one of the basic reading skills would then have been weighted equally for purposes of factorial analysis. However, authorities in the field of reading quite reasonably do not judge each one of the basic skills to be of equal importance in the process of reading comprehension. Of the many possible factorial analyses (using different weights), that analysis which appears to have unique merit is a principal-axes solution based on a matrix of variances and covariances in which the initial test variances are weighted to correspond with their relative importance in the process of reading, as determined by the pooled judgment of authorities. That is the type of factorial analysis that it was intended should be performed in the present study, but practical considerations resulted in some modifications in the relative weights of the nine initial variables.

For purposes of comparison, the Kelley method was used to perform a factorial analysis of the correlation matrix shown in Table 1 (excluding sex) with unit variances in the diagonals. A comparison of the factor loadings derived from the two principal-axes analyses and from a centroid analysis of the same data is now in preparation.

In Table 5 are presented the coefficients of each of the initial variables (the nine basic reading skills) that yield the nine independent components obtained by factorial analysis. The design shown in Table 5 is one of the most interesting that has been obtained by factorial techniques.

* For this study it was desirable to obtain the factor loadings of all significant components rather than the loadings for only the two or three largest components; hence a fairly large number of subjects was tested and Kelley's method was selected as being most suitable for use.

TABLE 5

Coefficients of Each of the Initial Variables That Yield Scores in the Nine Independent Components

(Factor Loadings of Skills 1-9 in Components I-IX)

Components	I	II	III	IV	V	VI	VII	VIII	IX	
Variance	192.270	22.824	8.657	5.282	3.828	3.306	2.327	1.956	1.006	
Skills										Variance
1	.813	−.571	−.064	−.033	−.082	.006	−.016	.001	.011	134.699
2	.184	.124	−.005	−.003	.971	−.019	−.017	−.028	−.076	10.563
3	.057	.054	−.001	.000	−.000	.000	.997	.000	−.004	3.009
4	.027	.048	−.000	.000	.067	.000	.000	.000	.996	1.220
5	.107	.149	.152	−.003	−.022	.970	−.014	−.024	−.012	6.050
6	.341	.469	.567	−.531	−.129	−.204	−.044	−.001	−.023	32.169
7	.336	.530	−.719	.008	−.147	−.020	−.051	−.091	−.028	33.752
8	.078	.105	−.001	.141	−.000	.000	−.010	.981	−.007	3.456
9	.233	.253	.366	.835	−.080	−.126	−.027	−.166	−.013	16.540

The subjective judgment exercised in constructing the tests of the nine reading skills is reflected in the surprising extent to which several of the tests appear to be moderately "pure" factor measures. A word of caution must, however, be injected. Because some of the skills were judged to be more important than others in the reading process and because practical considerations governed to some extent the number of items used to measure each of the nine reading skills, the standard deviations of the initial variables differed considerably. And, since the initial matrix of variances and covariances used for the analysis reflected those differences, the coefficients in Table 5 must be interpreted with due regard for the magnitudes of the standard deviations of the nine initial skills. Scores in skill 1, for example, have a large standard deviation in comparison with the standard deviations of scores in the other skills. So a small component loading in skill 1 may be found to have more weight in a regression equation for obtaining scores in any one of the components than would be expected from an inspection of Table 5 alone.*

* Readers who are most familiar with the centroid method of factorial analysis have sometimes questioned this statement. A principal-axes analysis makes it possible to obtain very readily a given individual's score in any one of the components for which regression coefficients (or factor loadings) have been determined. For example, individual scores in component I may be obtained from the following regression equation:

$$C_I = .813(X_1) + .184(X_2) + .057(X_3) + .027(X_4) + .107(X_5) + .341(X_6) + .336(X_7) + .078(X_8) + .233(X_9).$$

In this equation, variables 6 and 7 have nearly identical regression coefficients, but we know that the standard deviation of variable 6 is 5.67 while that of variable 7 is 5.81. Therefore, variable 7 will have a slightly greater weight in determining an individual's score in component I than will variable 6 despite the

A study of the values in Table 5 (making due allowance for the magnitudes of the standard deviations of the initial variables) reveals that the nine components are rather readily identifiable in terms of the original nine reading skills. Component I is clearly word knowledge (skill 1). Its positive loadings in each of the nine basic reading skills reflect the fact that to read at all it is necessary to recognize words and to recall their meanings.

It is clear that word knowledge plays a very important part in reading comprehension and that any program of remedial teaching designed to improve the ability of students to understand what they read must include provision for vocabulary building. When one combines the evidence that word knowledge is so important an element in reading with the fact that the development of an individual's vocabulary is in large measure dependent on his interests and his background of experience, the relatively low correlations between reading tests in different subject-matter fields are understandable.* There is, however, no necessity to conclude that all of the fundamental factors of comprehension in reading are *not* involved in reading materials in various subject-matter fields.

Component II has been termed a measure of reasoning in reading. It has its highest positive loadings in the two reading skills that demand ability to infer meanings and to weave together several statements. It may seem puzzling at first that this component should have a strong negative loading in skill 1 (word knowledge), but consideration of the psychological meaning of components I and II indicates that this should be expected. The explanation undoubtedly lies in the fact that individuals who know accurately the meanings of a great many words are thereby given a head start toward getting the meaning of what they read. Therefore, if we are to measure reasoning in reading independently of word knowledge, we must give individuals who are deficient in word knowledge a "handicap" and then see how well they reason when they are placed on equal terms with their fellows in word knowledge. Component II apparently measures the ability to see the relationships of ideas.

* For data on this point see (5).

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fact that the factor loadings of variables 6 and 7 in component I are almost the same.

A simple and convenient aid in interpreting the regression coefficients with proper regard for the sizes of the standard deviations of the initial variables is to construct a table containing each regression coefficient multiplied by the appropriate standard deviation of an initial variable. For example, the factor loading of skill 1 in component I (.813) would be multiplied by the standard deviation of skill 1 (11.61), yielding 9.4; the factor loading of skill 2 in component I (.184) would be multiplied by the standard deviation of skill 2 (3.25), yielding .6; and so on.

Component III is not so readily interpretable as most of the others, but it is clear that individuals who obtain high scores in this component focus their attention on a writer's explicit statements almost to the exclusion of their implications. Component IV measures chiefly the ability to identify a writer's intent, purpose, or point of view (skill 9). Individuals who obtain high scores in this component are less concerned with *what* a writer says than with *why* he says it. Such individuals should presumably be better able to detect bias and propaganda than individuals who obtain low scores in this component. Component V is composed principally of ability to figure out from the context the meaning of an unfamiliar word or to determine which one of several known meanings of a word is most appropriate in its particular contextual setting (skill 2). It is reasonable that it should be essentially unrelated to skill 1, which measures memory for isolated word meanings. The slight negative loadings of skills 6 and 7 in component V may result from the fact that the latter measures deductive reasoning, while skills 6 and 7 measure inductive processes.

Judging by its very high loading in skill 5, component VI seems to be largely a measure of ability to grasp the detailed statements in a passage. It is probably a fairly direct measure of the ability to get what I. A. Richards has called "the literal sense meaning" of a passage. Skill 5 was originally intended to measure this ability and the results of the analysis suggest that this ability is more than a name; it appears to be a real psychological entity distinct from other mental skills involved in reading. Component VII seems to be a measure principally of skill 3 (ability to follow the organization of a passage and to identify antecedents and references in it). The variance of this component consists of about 77% of the original variance of skill 3.

Component VIII measures specific knowledge of literary devices and techniques, and probably reflects the influence of training in English more than the other components do. Component IX is composed largely of ability to select the main thought of a passage; it may be considered a measure of ability in the synthesis of meaning. The variance of component IX comprises approximately 82% of the original variance of skill 4 (ability to select the main thought of a passage). Students who make high scores in component IX are presumably those who would be most capable of writing adequate summaries and précis of what they read.

Of the nine components described, all except components II, III, and IV can, for practical purposes, probably be measured satisfactorily by means of raw scores in one of the nine basic reading skills

selected initially. Components V through IX account for only a small fraction of the total variance, but their variances are significantly different.* A number of the skills considered most important by authorities in the field of reading include independent elements that should be taught separately. It is not enough to assign learning exercises in reading that consist of passages followed by factual questions to be answered. Such exercises will not necessarily call the student's attention to the separate and essentially unrelated reading skills that he ought to master or give him sufficient practice in each one of them.

TABLE 6
Variance Ratios of Successive Components

Component	Degrees of Freedom	Variance	F
I	406	192.270	8.280
II	399	22.824	2.663
III	403	8.657	1.622
IV	399	5.282	1.387
V	401	3.828	1.158
VI	401	3.306	1.428
VII	403	2.327	1.181
VIII	400	1.956	1.944
IX	400	1.006	

* The writer is indebted to Professor T. L. Kelley for the development of a precise test of the variance ratios of components obtained by his iterative process. This test is described in the article by Professor Kelley that immediately follows.

The differences between the variances of successive components are all significant at the one-per-cent level with the exception of the differences between the variances of components V and VI, and VII and VIII; those differences are significant approximately at the five-per-cent level.

It should be noted that the variance-ratio test of the significance of the difference between component variances is permitted by the Kelley method but is not permitted by other methods of factorial analysis that are frequently employed.

Whether the variance of component IX (the smallest component) is significantly greater than would be yielded by chance may be determined by noting whether the reliability coefficient of component IX is significantly greater than zero. This is not established by the data. It is highly likely, however, that the variance of the next largest component is significantly greater than would be yielded by chance.

TABLE 7

Reliability Coefficients, Means, and Standard Deviations of the Six Independent Components Having Reliability Coefficients Substantially Greater Than Zero

Component	r_{11}	Mean	Standard Deviation
I	.94	46.30	13.87
II	.48	24.14	4.78
III	.28	.81	2.94
IV	.17	- .62	2.30
VII	.33	.27	1.53
VIII	.29	.70	1.40

Because individual scores in each of the independent components defined above can readily be estimated by using appropriate regression equations (Cf. ante, footnote following Table 5), the reliability coefficients of scores in the nine components have been determined empirically, using the same sample of 100 cases for which odd and even scores in each variable were obtained in computing the reliability coefficients of the nine initial variables.

Inspection of Table 7 reveals that only components I and II are measured with sufficient reliability to warrant their use for practical purposes. However, when the significance of the reliability coefficient of each one of the nine components is tested,* it becomes evident that useful measures of at least three additional components could certainly be provided by constructing the required number of additional items of the appropriate types. Since several of the components may be satisfactorily measured, for practical purposes, by raw scores in appropriate types of test items, construction of a large number of the indicated types of items has already been started. It is believed that these may be useful for instructional as well as for measurement purposes when they are employed in combination with other workbook materials.

Since useful measures of components I and II are already available, a profile chart for making a graphic record of scores in these two components has been prepared and is described in considerable detail elsewhere (9).

The correlations of components I and II with the Q and L scores derived from the *American Council on Education Psychological Ex-*

* The standard error of a split-half reliability coefficient, corrected by the Spearman-Brown formula, may be obtained by using Shen's formula,

$$\sigma_{r_{11}} = \frac{2(1 - r_{11})}{\sqrt{N}}.$$

amination and with the total score on the *Nelson-Denny Reading Test* have also been reported in the literature (9, 370-371). It is hoped that the relationships between components I and II and other well-known reading tests can be obtained, for if components I and II are regarded as fundamental abilities in reading it is of paramount importance to determine the extent to which the reading tests now commonly used in high schools and colleges actually measure each of these abilities.

The study reported here has explored one means of investigating the psychological nature of reading ability. It has suggested a means of determining the validity of tests of comprehension in reading. The results indicate that there is need for reliable tests to measure several of the nine basic skills that have been defined and for workbooks to aid in improving students' abilities in them. The need for correlating scores in existing reading tests with scores in several of the principal components seems obvious. And, not least, the study provides more detailed information regarding the skills measured by the *Cooperative Reading Comprehension Tests* than has heretofore been provided regarding the skills actually measured by any other widely used reading test.*

Finally, it is hoped that the data presented will draw attention to the importance of the mental skills involved in reading and act as a stimulus to further research in the fundamental factors of comprehension.

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* Frederick B. Davis, et al., *The Cooperative Reading Comprehension Tests, Lower and Higher Levels, Forms Q, R, S,* and *T.* Eight separate 40-minute reading tests are now available and are distributed by the Cooperative Test Service, 15 Amsterdam Avenue, New York, N. Y., a nonprofit agency of the American Council on Education.

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