Extending the Measurement of Graduate Admission Abilities Beyond the Verbal and Quantitative Domains

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Traditionally, major national admissions tests, such as the Graduate Record Examinations (GRE) Aptitude Test, have focused primarily on the measurement of broadly applicable verbal and quantitative abilities. The GRE Board recently sponsored an investigation of the possibility of extending the measurement of abilities beyond the verbal and quantitative domains in order to facilitate a broadened definition of talent. That effort resulted in a restructured GRE Aptitude Test, which includes a measure of analytical ability for which a separate score is reported. The present study provides a factor analytic description of the new restructured test. Results suggest that the restructured test continues to tap the verbal and quantitative skills measured by the original GRE Aptitude Test but that it also contains a distinct, identifiable analytical dimension that is highly correlated with the dimensions underlying performance on the verbal and quantitative sections of the test.

Despite the complexity in the ability domain (see, e.g., Carroll & Maxwell, 1979), standardized tests of general academic ability have tended to focus almost exclusively on the measurement of two broadly applicable abilities—developed verbal and quantitative aptitude—and with good reason. These two constructs have been shown to be not only logically but also empirically related to successful study in a variety of fields (Willingham, 1974, 1976; Wilson, 1979).

The purpose of one such test of general academic ability, the Graduate Records Examinations (GRE) Aptitude Test, is to facilitate the selection of graduate school candidates. Until the fall of 1977, the test consisted of a verbal ability measure designed to test, according to Conrad, Trisman, and Miller (1977), "the ability to understand and manipulate written words in order to solve problems" (p. 10) and a quantitative ability measure designed to test "basic mathematical skills, understanding of elementary mathematical concepts, and ability to reason quantitatively and solve problems in a quantitative setting" (p. 14). The verbal section contained four principal item types: antonyms, analogies, sentence completions, and reading comprehension sets. The quantitative section consisted of three types: discrete mathematics, data interpretation, and quantitative comparison.

The Restructuring Effort

In 1974 a plan was developed to improve the GRE Aptitude Test by broadening its definition of academic talent beyond verbal and quantitative abilities (Altman, Carlson, & Donlon, 1975) in order to allow students to demonstrate a broader range of skills. After a survey of consti-

APPLIED PSYCHOLOGICAL MEASUREMENT
Vol. 5, No. 2, Spring 1981, pp. 141–158

0146-6216/81/020141-18$1.90

tuents revealed that faculty and administrators, as well as students, were most receptive to revising the test to include a measure of analytical or abstract reasoning skills, seven analytical item types were developed and evaluated with respect to a number of standards including reliability, efficiency, criterion-related validity, face validity, difficulty, speededness, and independence of verbal and quantitative measures (Conrad, 1976; Altman & Conrad, 1976). As a result, three analytical item types were selected for inclusion in the current measure of analytical skills, which has been a part of the GRE Aptitude Test since October 1977. The measure is described as tapping students' abilities to recognize logical relationships, to judge the consistency of interrelated statements, to use a sequential procedure to eliminate incorrect choices in order to reach a conclusion, to make inferences from statements expressing relationships among abstract entities such as nonverbal or nonnumerical symbols, and to determine relationships between independent or interdependent categories or groups. From 1977 until now, these abilities have been measured by three principal item types: analysis of explanations, logical diagrams, and analytical reasoning (Conrad et al., 1977), which are illustrated in Table 1. Substitutions for or modifications to these item types may be made before the analytical measure becomes fully operational.

Objectives

The major purpose of the study reported here was to develop a factor analytic description of the restructured GRE Aptitude Test. The methodology of factor analysis has been considered to be a useful approach to establishing the construct validity of measurement instruments (Cronbach, 1971). However, it is recognized that evidence of construct validity comes, not from a single study, but from a variety of related research efforts (American Psychological Association, 1974). The study reported here represents a correlational approach to establishing construct validity.

The secondary purposes of the investigation were (1) to provide additional information relevant to guiding the development of additional parallel forms of the analytical measure and (2) to compare the structure of the original test with the restructured test. Overall, this study was intended to provide some information relevant to the degree of progress toward the goal of broadened measurement of student talent.

Procedures

The Sample

Analyses reported here were based on a national random sample of approximately 4,000 examinees who took one form of the restructured GRE Aptitude Test during its first operational administration in October 1977. The item-level responses to all 205 items comprising the test constituted the raw data for the study. Other preliminary analyses also used the item-level responses of another random sample of nearly 6,000 examinees who took an equivalent form of the restructured test during the same administration.

Analyses

Analyses were performed in two stages. Preliminary item-level analyses of only the analytical sections of each of two equivalent forms of the test were conducted to gain a better understanding of the finer dimensions that might distinguish among the analytical items. Results of these analyses were seen as potentially relevant for developing tighter specifications for the new analytical measure. Analyses of two forms were used to assess the degree to which the new analytical forms had been successfully balanced on the basis of initial test specifications.

A second preliminary item-level solution was also obtained for one form using all verbal, quantitative, and analytical items. This solution was used, with test specifications, to form clusters of verbal, quantitative, and analytical items for the later parcel-based analyses. Matrices of

Table 1

Examples of the Three Analytical Item Types Used in the Restructured GRE Aptitude Test

Analysis of Explanations

Directions: **For each set of questions, a fact situation and a result are presented. Several numbered statements follow the result. Each statement is to be evaluated in relation to the fact situation and result.**

Consider each statement separately from the other statements. For each one, examine the following sequence of decisions, in the order A, B, C, D, E. Each decision results in selecting or eliminating a choice. *The first choice that cannot be eliminated is the correct answer.*

A **Is the statement *inconsistent* with, or contradictory to, something in the fact situation, the result, or both together?**
If so, choose A.
If not,

B **Does the statement present a *possible adequate explanation* of the result?**
If so, choose B.
If not,

C **Does the statement have to be true if the fact situation and result are as stated?**
If so, the statement is *deducible* from something in the fact situation, the result, or both together; choose C.
If not,

D **Does the statement either support or weaken a possible explanatiion of the result?**
If so, the statement is *relevant* to an explanation; choose D.

E **If not, the statement is *irrelevant* to an explanation of the result; choose E.**

Use common sense to decide whether explanations are adequate and whether statements are inconsistent or deducible. No formal system of logic is presupposed. Do not consider extremely unlikely or remote possibilities.

Situation: **In an attempt to end the theft of books from Parkman University Library, Elnora Johnson, the chief librarian, initiated a stringent inspection program at the beginning of the fall term. At the library entrance, Johnson posted inspectors to check that each library book leaving the building had a checkout slip bearing the call number of the book, its due date, and the borrower's identification number. The library retained a carbon copy of this slip as its only record that the book had been checked out. Johnson ordered the inspectors to search for concealed library books in attaché cases, bookbags, and all other containers large enough to hold a book. Since no new personnel could be hired, all library personnel took turns serving as inspectors, though many complained of their embarrassment in conducting the searches.**

Result: **During that term Margaret Zimmer stole twenty-five library books.**

1. **Zimmer stole the books before the inspection system began.** (Correct response A)
2. **Zimmer dropped the books out of a second-story window into a clump of bushes and retrieved them after she left the building.** (Correct response B)
3. **During that term, if Zimmer carried a bookbag out of the library entrance door during regular hours, an inspector was supposed to check it.** (Correct response C)
4. **The doors to the library fire escapes are equipped with alarm bells set off by opening the doors.** (Correct response D)
5. **The library had at one time kept two carbon copies of each checkout slip.** (Correct response E)

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Table 1, continued

Analytical Reasoning

Analytical Reasoning. Analytical reasoning consists of complex sets of statements from which the student must draw inferences. The statements may include abstractions such as symbols without specific referents. The directions and sample questions appear below. An asterisk denotes the correct response.

Directions: **Each question or group of questions is based on a passage or set of statements. In answering some of the questions it may be useful to draw a rough diagram. Choose the best answer for each question and blacken the corresponding space on your answer sheet.**

Questions 1–2

(1) It is assumed that a half tone is the smallest possible interval between notes.
(2) Note T is a half tone higher than note V.
(3) Note V is a whole tone higher than note W.
(4) Note W is a half tone lower than note X.
(5) Note X is a whole tone lower than note T.
(6) Note Y is a whole tone lower than note W.

1. Which of the following represents the relative order of the notes from the lowest to the highest?

(A) X Y W V T *(B) Y W X V T (C) W V T Y X
(D) Y W V T X (E) Y X W V T

2. Which of the following statements about an additional note, Z, could NOT be true?

(A) Z is higher than T. (B) Z is lower than Y.
(C) Z is lower than W. (D) Z is between W and Y.
***(E) Z is between W and X.**

Questions 3–4

(1) You cannot enter unless you have a red ticket.
(2) If you present a blue form signed by the director, you will receive a red ticket.
(3) The director will sign and give you a blue form if and only if you surrender your yellow pass to him.
(4) If you have a green slip, you can exchange it for a yellow pass, but you can do so only if you also have a blue form signed by the director.
(5) In order to get a red ticket, a person who does not have a driver's license must have a blue form signed by the director.
(6) You can get a yellow pass on request, but you can do so only if you have never had a green slip.

3. The above precedures fail to specify

***(A) whether anything besides a red ticket is required for entrance**
(B) whether you can exchange a green slip for a yellow pass
(C) the condition under which the director will sign the blue form
(D) how to get a red ticket if you have a yellow pass
(E) whether it is possible to obtain a red ticket if you do not have a driver's license

4. Which of the following people can, under the rules given, eventually obtain a ticket?

I. A person who has no driver's license and who has only a green slip
II. A person who has no driver's license and who has only a yellow pass
III. A person who has both a driver's license and a blue form signed by the director

(A) I only (B) II only (C) I and II only
***(D) II and III only (E) I, II, and III**

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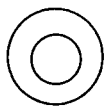
Table 1, continued

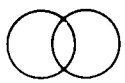
Logical Diagrams

Directions: **In this part, you are to choose from five diagrams the one that illustrates the relationship among the given classes better than any of the other diagrams offered.**

There are three possible relationships between any *two* different classes:



indicates that one class is completely contained in the other, but not vice versa.



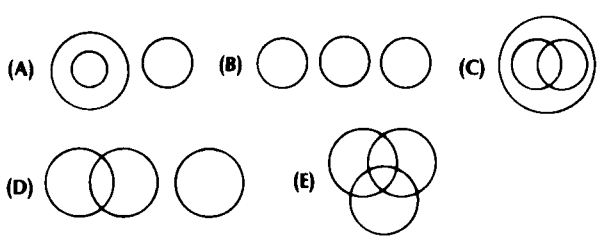
indicates that neither class is completely contained in the other, but the two do have members in common.

indicates that there are no members in common.

Note: **The size of the circles does *not* indicate relative size of the classes.**

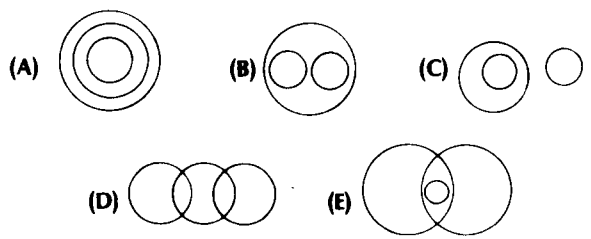
Example:

Birds, robins, trees



The correct answer, (A), shows that one of the classes (trees) has no members in common with the other two. (No trees are either birds or robins, and no birds or robins are trees.) (A) also shows that one of the two remaining classes (robins) is completely included in the other class (birds).

The five possible choices for all problems in this part are given below.



1. **Nuts, pecans, forks** (Correct response C)

2. **Adult women, infants, black-haired people** (Correct response D)

3. **Fish, minnows, things that live in water** (Correct response A)

tetrachoric coefficients were subjected to initial principal axis factoring to determine the approximate number of factors to be retained in each case. Both the magnitude of eigenvalues and the breaks in their size were used to decide the appropriate number of factors to be designated for subsequent minres solutions (Harman & Jones, 1966) from which communality estimates were produced. The resulting factors were rotated according to several rotational schemes, both orthogonal and oblique, including varimax (Kaiser, 1958), oblimin (Jennrich & Sampson, 1966), and geoplane (Yates, 1974, 1978, 1979).[1] These first-stage exploratory analyses not only served to better understand the more molecular dimensions underlying performance on the test but also formed the basis for specifying homogeneous subsets or parcels of items upon which the major second-stage analyses were based.

The use of item parcels was preferred for several reasons but mainly to circumvent some of the problems often encountered in using inter-item correlations. For example, it is commonly held that spurious difficulty factors may arise from item-level factor analyses. Nonlinearity may lead to the emergence of some factors defined by easy items and others marked by difficult items, even though the underlying continuum is unidimensional. In addition, parcel subscores are more reliable than individual items and should therefore be less susceptible than the latter to the emergence of difficulty factors arising from instability, although nonlinearities arising from guessing are not removed by combining items. Finally, the reporting of results based on a smaller number of parcels is less cumbersome than one based on a larger number of items.

The rationale for using subsets of items here parallels a solution to the item versus subset controversy given by Cattell and Burdsal (1975), who cite two fundamental approaches to forming item parcels. The first, grouping of items by apparent content, is rejected as being too subjective; the second, grouping items according to their intercorrelations, is dismissed as being somewhat destructive of inherent simple structure. Their recommendation to perform two factor analyses—one based on individual items and the other on the parcelled item variables that result from the item-level factoring—has been followed in this study.

In specifying the item parcels for the second-level analysis, certain decisions were needed. When certain item characteristics were confounded with item type (e.g., reading comprehension items tended to be less difficult than vocabulary items), clustering based on only one attribute effectively foreclosed the possibility that other attributes might define factors. The prior item-level factoring, however, allowed rational choices in assigning items to parcels so as not to mask certain important sources of variance suggested from the initial analyses. Important sources of variance that emerged from these initial analyses were nominal item type, item difficulty within certain item types, keyed response choice for certain fixed-format items, content for certain items (e.g., algebraic, geometric, or arithmetic content for mathematics items), and passage, or diagram, dependencies for certain items. Since the evidence for speed factors was weak in the item-level results, the position of items at the end of separately timed sections was not considered in specifying parcels. The item-level results have been reported in detail elsewhere

[1]Geoplane is a hyperplane-location approach that yields an oblique solution. The objective of cluster-oriented rotational schemes (such as varimax and oblimin) is usually to associate each variable with a single factor. Under the geoplane criterion, factors are defined by virtue of the set of variables to which they are *unrelated* and the variables themselves are permitted to be factorially complex. Greater freedom exists in the choice of factor axes when planes or hyperplanes, rather than reference axes, are chosen to represent clusters of variables (Harman, 1976, p. 96). The geoplane criterion "encourages" variables to be of less than full factorial complexity but does not "force" any of them to be unifactorial as the cluster-oriented schemes are prone to do. On the contrary, the geoplane criterion, by minimizing the geometric mean of squared loadings of variables on factors, demands only that each variable have a near-zero loading on at least one factor (i.e., that each lie in a hyperplane *not* containing *some* factor).

(Swinton & Powers, 1979). Thus, except for speededness, all dimensions that had emerged from item-level analyses were afforded the opportunity to appear in item parcels.

The 205 items were divided into 53 item parcels consisting of either three or (in most cases) four items. Except for using product-moment correlations instead of tetrachoric coefficients, all item parcels were subjected to the same factor analytic procedures used to analyze the item-level data.

Finally, item-parcel solutions, based on both varimax and geoplane rotations, were extended to background information (Dwyer, 1937; Harman, 1938) to facilitate the interpretation of factors. The results of this extension analysis have also been described in more detail elsewhere (Swinton & Powers, 1979).

Results

The item-parcel groupings that resulted from preliminary item-level analyses are shown in Table 2, which also shows the number of items in each parcel as well as the mean and standard deviation of scores for each parcel. The largest eigenvalues resulting from a principal components analysis of these parcels were 33.29, 6.23, 3.66, 2.34, 1.62, 1.39, 1.09, 1.05, .91, and .81. Although eight eigenvalues were greater than one, the application of a scree test (Cattell, 1966) suggested that six factors would be appropriate. Three, four, five, and six factors were rotated and examined before the final decision was made to base the description of item parcels on the six-factor solution. A final six-factor minres solution, which accounted for 90.4% of the total estimated common variance, was rotated according to the oblimin, varimax, and geoplane criteria. Only the results of the latter two rotations are presented here, since the oblimin rotation (Swinton & Powers, 1979) did not yield a reasonable simple structure.

Varimax Solution

The varimax rotation produced three substantial factors, which accounted for nearly 80% of the common variance, and three less prominent factors, each accounting for about 7% of the common variance (see Table 3).

The communalities computed for the item parcels, although not as high as those usually reported for longer tests, were in general higher than those computed for the item-level solutions. Approximately 57% of the item cluster communalities were greater than .40, compared with about 46% of the item-level communalities. Furthermore, only about 11% of the parcel communalities were very low (less than .30), compared with 28% of those computed for individual items. Thus, there is some evidence for the greater reliability of clusters of items.

Factor I, reflecting 31.1% of the total common variance, was defined by high loadings from sentence completions, reading comprehension items, and two analytical item types. High loadings on this factor were also noted for several parcels of easy discrete verbal items (antonyms and analogies). Factor I was labeled "verbal reasoning." Because the similarity of analysis of explanation items to reading comprehension items in their use of questions with narrative passages is apparent, it is probably not surprising that these two item types should load on a common factor. However, the fact that logical diagram items also helped define Factor I is somewhat more problematic, suggesting perhaps that this factor also reflects a more general verbal and classificatory reasoning ability.

Factor II accounted for slightly more than 25% of the common variance. Because of high loadings from nearly all quantitative parcels, it was termed "general quantitative ability." Similar to Factor I, however, this factor also had some relatively high loadings from analytical item parcels.

Factor III, reflecting 22.8% of the total common variance, was defined primarily by loadings from antonym and analogy items, especially the more difficult ones, and was thus viewed as a "vocabulary" factor. A few substantial loadings also came from sentence completions and reading comprehension items employing relatively difficult vocabulary.

Table 2
Item Parcel Designations and Their Means and Standard Deviations

Number	Name	Number of Items	Mean No. Correct	S.D.
Verbal				
1	SC (easy)	4	2.98	1.04
2	SC (easy)	4	2.95	1.06
3	SC (difficult)	4	1.94	1.18
4	SC (difficult)	4	1.39	1.24
5	AN (easy)	4	1.80	1.25
6	AN (easy)	4	3.28	.88
7	AN (difficult)	4	.85	1.04
8	AN (difficult)	4	.77	1.03
9	OPP (very difficult)	4	.52	.91
10	OPP (difficult)	4	.93	1.02
11	OPP (mid difficult)	4	1.73	1.25
12	OPP (easy)	4	1.85	1.35
13	OPP (very easy)	4	3.23	1.02
14	RCP1	3	2.43	.80
15	RCP2	3	1.74	.88
16	RCP3 (difficult)	4	2.20	1.37
17	RCP3 (easy)	4	2.87	1.19
18	RCP4	3	1.47	1.03
19	RCP5 (difficult)	4	1.85	1.49
20	RCP5 (easy)	4	2.75	1.48
Quantitative				
21	QC choice D (difficult)	3	.90	.88
22	QC choice D (easy)	3	1.77	.96
23	QC choice A,B,C (very difficult)	4	1.13	1.08
24	QC choice A,B,C (difficult)	4	1.68	1.09
25	QC choice A,B,C (mid difficult)	4	2.54	1.00
26	QC choice A,B,C (easy)	4	3.07	1.00
27	QC choice A,B,C (easy)	4	3.28	.96
28	QC choice A,B,C (very easy)	4	3.70	.65
29	DI	4	2.96	1.10
30	DI extraction	3	2.21	1.02
31	DI manipulation	3	1.60	1.10
32	Q (easy)	3	2.16	.79
33	GEOM	4	1.69	1.19
34	ALG	4	1.14	.98
35	Word Problems	4	1.94	.92

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Table 2, continued

Number	Name	Number of Items	Mean No. Correct	S.D.
Analytic				
36	AX choice A	4	2.95	1.01
37	AX choice B	5	3.39	1.47
38	AX choice C	4	2.10	1.27
39	AX choice D	3	1.17	.98
40	AX choice E	4	2.96	1.10
41	AX choice D	4	1.76	1.33
42	AX choice C	3	1.65	1.14
43	AX choice A,B,E	4	2.59	1.10
44	AX choice A,B,E	4	2.36	1.30
45	AX choice D	5	1.81	1.44
46	LD (difficult)	4	1.74	1.21
47	LD (mid difficult)	3	1.77	1.13
48	LD (mid easy)	4	2.87	1.25
49	LD (very easy)	4	3.40	.91
50	AR (Set 1)	3	2.22	.89
51	LR	4	2.49	1.22
52	AR (Set 2)	4	2.84	1.43
53	AR (Set 3)	4	1.50	1.19

ALG = Algebra
AN = Analogies
AR = Analytical Reasoning
AX = Analysis of Explanations
DI = Data Interpretation
GEOM = Geometry
LD = Logical Diagrams
LR = Logical Reasoning
OPP = Opposites
QC = Quantitative Comparison
RCP(N) = Reading Comprehensive Passage (Number)
SC = Sentence Completion

Factor IV had very high loadings from two parcels based on items associated with a technical reading passage. This factor accounted for 7.1% of the test's common variance.

Factor V, which also represented about 7% of the total common variance, is quantitative in nature, primarily reflecting performance on three parcels of "data interpretation" items.

Factor VI also accounted for nearly 7% of the Aptitude Test's common variance and was defined as "analytical ability" by virtue of high loadings from nearly all of the analytical item parcels but from none of the verbal or quantitative item parcels.

Thus, the orthogonal varimax rotation of factors based on item parcels yielded three major factors, the first of which covaried strongly with verbal items, particularly reading comprehension and sentence completion items (which also tend to be somewhat easier than are most discrete verbal items), and with analytical items. The second factor covaried with both quantitative items and analytical items. Thus, from this solution, it would appear that analytical items are essentially describable in terms of verbal and quantitative factors but not vocabulary factors, and that these items show only modest variation that can be described as unique to their item

Table 3
Varimax Factor Loadings for Item Parcel Analysis

Parcel Code[a]	Parcel Number	Factor[b] I	II	III	IV	V	VI	Communality
Verbal								
SC	1	54	20	33				46
SC	2	55		32				46
SC	3	37		48				43
SC	4	31		61				51
AN	5	36		55				47
AN	6	56						39
AN	7			69				54
AN	8			72				55
OPP	9			62				41
OPP	10			64				43
OPP	11	24		67				52
OPP	12	27		66				55
OPP	13	60		31				50
RCP1	14	58						41
RCP2	15	37	36					34
RCP3	16	46		30	22			37
RCP3	17	52		22	22			39
RCP4	18	37	21	32	29			38
RCP5	19	26		26	67			64
RCP5	20	33			68			66
Quantitative								
QC	21		51					33
QC	22	25	57					42
QC	23		56					38
QC	24		49					25
QC	25		56					36
QC	26	30	55					39
QC	27	35	52					40
QC	28	30	44					30
DI	29	35	41			23		36
DI	30	25	26			55		46
DI	31		32			58		50
Q	32		50					29
GEOM	33		71					58
ALG	34		44			22		29
Word Problems	35	21	47			31		41

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Table 3, continued

Parcel Code[a]	Parcel Number	Factor[b] I	II	III	IV	V	VI	Communality
Analytic								
AX-A	36	48	21					30
AX-B	37	49	25				22	37
AX-C	38	37	24				23	27
AX-D	39	24	27	22			28	27
AX-E	40	48						32
AX-D	41	33	34	25			31	40
AX-C	42	41					29	31
AX	43	51					26	41
AX	44	36				33	30	41
AX-D	45	26	28	26		25	40	47
LD	46	35	36	23			30	41
LD	47	46	42				37	54
LD	48	52	44				30	57
LD	49	59	23					44
AR	50	26	34					21
LR	51	46	20	27				43
AR	52	35	24					26
AR	53	21	29			29	25	34
Common Variance		6.79	5.62	4.98	1.55	1.48	1.43	21.85

[a] See Table 1 for Item Parcel codes.

[b] Factors: I Verbal Reasoning; II Quantitative; III Vocabulary; IV Technical Reading Comprehension; V Data Interpretation; VI Analytic

Note. Loadings less than .20 have been omitted, as have all decimal points.

type. That is, the analytical items comprising the analytical section of the Aptitude Test appear to have more variance in common with a general comprehension or reasoning factor than with the minor analytical factor.

However, the restriction to orthogonal factors may result in an oversimplified representation of the test's structure. Since it is probably unreasonable to expect the abilities of various verbal, quantitative, and analytical item types to be independent or uncorrelated in the population of GRE test takers, an oblique geoplane solution was obtained.

Geoplane Solution

The results of the geoplane rotation of six factors are given in Table 4. Factor I′, accounting for 18.3% of the common variance, was viewed as a "reading comprehension" factor because of its large loadings from reading passages, easier sentence completion items, and easy discrete verbal items. One negative and several near-zero loadings from difficult verbal items, principally the discrete types, supported the interpretation of this factor.

Table 4
Geoplane Factor Pattern (Partial Correlations) for Item Parcel Analysis

Parcel Code[a]	Parcel Number	Factor[b] I′	II′	III′	IV′	V′	VI′	Communality
Verbal								
SC	1	47						44
SC	2	54						44
SC	3	36		30				44
SC	4			57				52
AN	5	38		42				47
AN	6	47						37
AN	7			72				56
AN	8			70				51
OPP	9	-25		70				40
OPP	10			65				42
OPP	11	22		65				54
OPP	12			72				59
OPP	13	67						49
RCP1	14	59						39
RCP2	15	43	33					36
RCP3	16	53						37
RCP3	17	60						39
RCP4	18	49						39
RCP5	19	37				31		38
RCP5	20	42				41		41
Quantitative								
QC	21		56					35
QC	22		50					43
QC	23		63					40
QC	24		59					27
QC	25		51					37
QC	26		36				27	37
QC	27		30				31	37
QC	28						55	39
DI	29	22					25	37
DI	30					46		35
DI	31					43		34
Q	32		38				30	31
GEOM	33		70					59
ALG	34		43			21		30
Word Problems	35		38			23		39

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Table 4, continued

Parcel Code	Parcel Number	Factor[a] I′	II′	III′	IV′	V′	VI′	Communality
Analytic								
AX-A	36	27			23			29
AX-B	37				44			38
AX-C	38				30			27
AX-D	39				24			25
AX-E	40	23			34			30
AX-D	41		22		31			39
AX-C	42				38			29
AX	43				38			38
AX	44				29	43		41
AX-D	45				32	39		45
LD	46		26		38			41
LD	47		21		54			52
LD	48				53			57
LD	49	32			35			45
AR	50		27					22
LR	51	34			21	20		44
AR	52	21				22		27
AR	53				20	46		38
Common Variance		3.52	4.39	4.06	3.54	2.29	1.41	19.21

[a]See Table 1 for Item Parcel codes.

[b]Factors: I′ Reading Comprehension; II′ General Quantitative; III′ Vocabulary; IV′ Analytic; V′ Data Interpretation/ Technical Comprehension; VI′ Elementary Quantitative

Note. Loadings less than .20 have been omitted, as have all decimal points.

Factor II′ had high loadings from all of the quantitative parcels except those that were very easy and those that consisted of data interpretation items. This factor explained 22.8% of the test's common variance and is identified here as "general quantitative ability."

Factor III′, reflecting 21.2% of the total common variance among parcels, was characterized nearly exclusively by very high loadings from all discrete verbal items except each of the very easiest antonym and analogy parcels. It also had two relatively high loadings from two difficult sentence completion parcels, which tend to have difficult vocabulary. This dimension was therefore interpreted to be a "vocabulary" factor.

Factor IV′, which explained 18.4% of the parcels' common variance, received its highest loadings from parcels composed of items of the logical diagram analytical type, followed by analysis of explanation items. This factor appeared, then, to reflect a type of analytical ability.

Factor V′ explained 11.9% of the common variance. This factor is related to data interpretation parcels, the technical reading passages, and speed associated with several parcels of analyti-

cal items located at the end of separately timed sections of the test. This factor is referred to here as data interpretation/technical comprehension, an ability that is apparently also associated with quickness in responding to analytical items. It should be noted that the analysis of explanation parcels that load on this factor have items based on a passage about hospital statistics, a passage that appears similar to data interpretation items and to the technical reading passage in content and style.

The final geoplane factor, Factor VI′, reflected performance on several parcels of easy quantitative items. It accounted for 7.3% of the parcels' common variance and was termed easy or "elementary quantitative ability."

The intercorrelations among the geoplane factors (see Table 5) show a strong relationship (r =.66) between the reading comprehension and the analytical ability factors and substantial correlations (.54 and .56) between general quantitative and analytical ability and between reading comprehension and vocabulary. However, although correlated, the factors are distinct in their interpretation.

In summary, if one wishes to describe the structure of item parcels in terms of orthogonal factors, it appears that analytical items are primarily explained by a reading comprehension factor, to a somewhat lesser extent by quantitative ability, and to an even lesser extent by a minor dimension possessing a more distinctly analytical flavor. However, if one allows correlated factors, the geoplane rotation identifies a distinct and more prominent, although strongly correlated, factor that reflects a component of analytical ability. This latter interpretation leaves open the possibility that the analytical and reading comprehension scales may yield differential predictive validity.

It is important to remember that correlated factors are involved here and that high factor *pattern* loadings represent those components of item variance unique to a factor. In an oblique solution, variables may exhibit higher pattern loadings on one factor although they may have higher correlations (factor structure coefficients) with another. Indeed, in the case of the geoplane solution, this is precisely what occurred with reading comprehension passages.

Table 6 gives the geoplane factor structure showing correlations of factors within the item parcels. Although reading passages have high pattern loadings (partial correlations) on Factor I′and near-zero loadings on Factor IV′, examination of the projections (zero-order correlations) of the variables on the factors reveals that reading passages are slightly more highly correlated with Factor IV′ than with Factor I′, the "reading comprehension" factor. Thus, although Factor I′ represents the dimension unique to reading passage items, it does not necessarily represent a typical reading passage item. The orthogonal varimax result, in which reading comprehension and analytical items loaded on a single general verbal reasoning factor, is thus

Table 5
Geoplane Factor Correlations

Factor		I′	II′	III′	IV′	V′
I′	Reading Comprehension					
II′	Quantitative	.42				
III′	Vocabulary	.56	.37			
IV′	Analytic	.66	.54	.38		
V′	Data Interpretation/ Technical Comprehension	.51	.50	.41	.42	
VI′	Easy Quantitative	.34	.36	-.02	.40	.21

Table 6
Geoplane Factor Structure (Zero-order Correlations) for Item Parcel Analysis

Parcel Code[a]	Parcel Number	Factor[b] I′	II′	III′	IV′	V′	VI′	Communality
Verbal								
SC	1	44	37	44	49	37	28	44
SC	2	44	31	43	47	37	24	44
SC	3	44	38	56	44	38		44
SC	4	52	34	69	40	37		52
AN	5	47	32	62	37	36		47
AN	6	37	29	32	46	31	32	37
AN	7	56	33	75	33	33		56
AN	8	51	23	71	25	30		51
OPP	9	40	42	62	24	24		40
OPP	10	42	20	64	22	23		42
OPP	11	53	29	72	30	27		54
OPP	12	59	32	75	39	38		59
OPP	13	49	30	43	46	34	25	49
RCP1	14	39	26	32	45	29	27	39
RCP2	15	36	48	31	42	34	26	36
RCP3	16	37	27	41	43	33		37
RCP3	17	39	25	34	41	37	20	39
RCP4	18	39	39	44	42	40		39
RCP5	19	38	35	40	35	52		38
RCP5	20	41	27	32	36	56		41
Quantitative								
QC	21	35	58	22	36	28		35
QC	22	43	62	21	46	32	40	43
QC	23	40	63	26	35	31		40
QC	24	27	50					27
QC	25	37	59	24	35	30	36	37
QC	26	37	52		41	30	45	37
QC	27	37	49		43	26	49	37
QC	28	39	37		35	24	59	39
DI	29	37	48	24	40	41	43	37
DI	30	35	36	23	34	55	32	35
DI	31	34	44	25	32	55	24	34
Q	32	31	49		29	29	41	31
GEOM	33	59	75	28	37	42	36	59
ALG	34	30	51	20	31	40		30
Word Problems	35	39	57	28	40	48	31	39

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Table 6, continued

Parcel Code[a]	Parcel Number	Factor[b] I′	II′	III′	IV′	V′	VI′	Communality
Analytic								
AX-A	36	29	31	26	48	27	33	29
AX-B	37	38	36	24	60	31	34	38
AX-C	38	27	37	28	48	27		27
AX-D	39	25	40	32	43	32		25
AX-E	40	30	31	24	52	27	28	30
AX-D	41	39	49	39	55	41	20	39
AX-C	42	29	30	26	51	35		29
AX	43	38	34	29	57	40	29	38
AX	44	41	35	32	50	57	23	41
AX-D	45	45	46	40	52	58		45
LD	46	41	50	36	58	35	20	41
LD	47	52	53	32	69	35	34	52
LD	48	57	53	29	72	33	44	57
LD	49	45	34	29	60	30	40	45
AR	50	22	41		37	29	24	22
LR	51	44	39	41	54	49	20	44
AR	52	27	34	21	43	41	25	27
AR	53	38	42	32	42	58		38
Common Variance		3.52	4.39	4.06	3.54	2.29	1.41	19.21

[a] See Table 1 for Item Parcel codes.

[b] Factors: I′ Reading Comprehension; II′ General Quantitative; III′ Vocabulary; IV′ Analytic; V′ Data Interpretation/ Technical Comprehension; VI′ Elementary Quantitative

Note. Loadings less than .20 have been omitted, as have all decimal points.

not inconsistent with the geoplane description. Indeed, the pattern of correlations of geoplane Factors I′ and IV′ are both generally similar to that of the varimax verbal reasoning factor, the major difference being in the lower contribution of the latter from quantitative item parcels.

Geoplane Factor I′ is seen as more closely correlated with discrete verbal items and less with analytical items than is Factor IV′, analytical ability. The varimax general verbal reasoning factor, Factor I, can be thought of as being near the centroid of geoplane Factors I′ and IV′. Then, the minor varimax analytical factor, Factor VI, defining a dimension of analytical ability orthogonal to reading comprehension, quantitative ability, and most analytical item variance, may be thought of as representing a dimension of contrast between the geoplane reading comprehension and the geoplane analytical ability factors. Thus, the varimax and geoplane "analytical" factors are not closely related, apparently tapping quite different aspects of analytical ability.

Summary and Discussion

From a factor analytic viewpoint, the goal of broadening the measurement of academic abil-

ities beyond the verbal and quantitative domains appears to be attainable. The verbal and quantitative dimensions that underlie the restructured test remain quite similar to those reflecting performance on the original test. The two major verbal factors (vocabulary and reading comprehension) and the major quantitative factor extracted in this investigation correspond directly to the factors computed for the original test (Powers, Swinton, & Carlson, 1977). This was expected, since except for the introduction of an additional quantitative item type, the verbal and quantitative types are the same for the new test as for the old one. Other less prominent verbal and quantitative dimensions related to item type and content of reading passages also remained quite similar for both tests. Results of this study suggest also that a distinct, identifiable analytical dimension has been introduced into the GRE Aptitude Test, although this factor is highly related to the other factors underlying performance on the test for the population of GRE candidates. This factor is defined predominately by the three new analytical item types but not by any of the verbal or quantitative item types.

One criticism of such omnibus verbal and quantitative ability measures as the GRE Aptitude Test is that they provide only a limited description of students' academic strengths and weaknesses (i.e., they do not adequately reflect either the diversity of candidates' backgrounds and experiences or their differential development in other important cognitive areas). The introduction of an analytical component to the test may serve to provide a more multidimensional definition of academic talent that may serve not only selection purposes but also guidance and placement functions. A more comprehensive picture of students' abilities seems especially appropriate for the GRE Aptitude Test, which must serve numerous graduate departments having very different orientations. Once the new measure is fully operational, its actual utility can be determined only by further monitoring its use and evaluating its impact.

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Acknowledgments

This paper is based on a presentation given at the annual meeting of the National Council in Measurement in Education (NCME), San Francisco, 1979. The authors acknowledge the support of the Graduate Record Examinations Board in conducting this research, and that of Bert Green for helpful comments, Dorothy Thayer for programming the analyses, and Chris Rushinski for typing the report.

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