Ability Factor Differentiation, Grades 5 Through 11

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Factor analyses have been computed in samples of white male and female and black male and female students for the same 16 cognitive variables at grade levels 5, 7, 9, and 11. Samples for each of the four independent groups remained constant at the four grade levels. The latent roots as analyzed in three ways show a clear but small increase in the number of common factors during this time period, particularly for the white groups. Rotated factor loadings also support the differentiation hypothesis. For the white males, who showed the clearest evidence for differentiation of abilities, rotated loadings provide descriptions of the emerging factors. Although the evidence for differentiation is less clear in white females, the emerging factors appear to become identical by the 11th grade. Data for black males and females, which are based on smaller Ns, are more ambiguous.

The hypothesis of differentiation of abilities during maturation has a long history, but the evidence is conflicting. Anastasi (1958) summarized the history of the hypothesis and the evidence concerning it almost 20 years ago, and little definitive evidence has been accumulated since. (See Anastasi, 1970, and Reinert, 1970). Numerous problems are involved. Data obtained before and during the public school period more or less represent the full range of human talent. In the full range of ability a general factor contributes so much variance that it tends to mask the much smaller group factors. When the analyses are done with independent groups representing the several age levels, sampling variability from group to group is usually so large that a possible increase in the number of factors is difficult to determine; i.e., the increase in size may be smaller than the sampling error at any given age. The decision concerning the number of factors is also something less than objective since different criteria provide different answers. Fitzgerald, Nesselroade, and Baltes (1973), for example, relied heavily on a highly fallible though popular criterion, number of latent roots greater than unity, for determining the number of common factors. Use of this criterion can frequently lead to overlooking small but replicable factors (Humphreys, 1964).

A difficulty of quite a different sort is the lack of any guidance concerning the ages at which specific kinds of differentiation should occur. Research has typically proceeded blindly using several ages and several different kinds of tests, but differentiation may have occurred for a set of measures at earlier or later ages than those represented in a given research design. Thurstone's primary mental abilities may be differentiated, for example, in the preschool period.

Several criteria for a better controlled study emerge from this brief survey of past difficulties. First, the study should be designed to minimize

APPLIED PSYCHOLOGICAL MEASUREMENT
Vol. 1, No. 1 Winter 1977 pp. 65–76

the "noise" contributed by sampling error to the factors and factor loadings. A longitudinal design is very effective for this purpose. Second, there should be more than two occasions represented on the grounds that differentiation should be gradual and monotonic. Third, the number of factors decision should be made with great care and on the basis of the best criteria available. Fourth, the tests administered should be subject to differentiation on the basis of the age and experience background of the subjects.

Method

The growth data collected by the Educational Testing Service (Hilton, Beaton, and Bower, 1971) were made available to the present authors for analysis. Essentially the same 16 cognitive variables were administered to students in grades 5, 7, 9, and 11. While representing the same content, more than one form of each of the tests was used in order to accommodate to the increased knowledge of the examinees as they progressed through the grades. The tests used are listed in Table 1.

Although substantially more than 10,000 students participated in one or more of the four administrations, complete data (16 test scores at each of four occasions plus sex and race) were only available for a relatively small subset. This subset was divided into four groups defined by race (black and white) and by sex. The Ns available are as follows: white males, 668; black males, 172; white females, 762; black females, 215. Also presented are the means and standard deviations of each of the four grade levels for the combined white groups.

Principal axes were extracted from the correlation matrix in which squared multiple correlations had been inserted in the main diagonal. The number of factors was determined by means of the parallel analysis criterion (Humphreys and Ilgen, 1969; Humphreys and Mon-

Table 1
Identification of the Measures and Their Means and Standard Deviations in the Combined White Groups

		Grade 5		Grade 7		Grade 9		Grade 11	
	Test	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
1.	STEP[1] Mathematics	248.7	9.8	261.4	12.6	272.0	12.6	278.7	14.3
2.	STEP Physical Science	256.0	11.6	267.0	11.0	275.3	13.3	282.8	12.3
3.	STEP Social Science	253.0	11.0	263.5	13.1	275.1	14.3	280.5	14.2
4.	STEP Reading	260.9	15.0	273.4	16.7	285.2	15.1	296.2	16.4
5.	STEP Listening	270.1	11.2	280.1	13.1	287.6	14.4	293.5	14.0
6.	STEP Writing	258.9	13.4	267.6	15.7	281.3	16.9	291.1	17.5
7.	SCAT[2] Verbal	251.4	11.2	265.4	11.7	278.5	12.2	285.2	13.8
8.	SCAT Quantitative	258.1	8.0	276.3	12.4	291.1	15.3	296.8	16.4
9.	TGI[3] Industrial Arts	5.91	2.9	5.86	2.5	5.74	2.5	6.90	2.7
10.	TGI Home Arts	7.29	2.7	6.85	2.3	7.72	2.5	9.33	2.4
11.	TGI Physical Science, Mathematics	6.74	2.9	6.29	2.1	7.03	2.6	8.00	2.7
12.	TGI Biological Science	7.39	3.0	6.78	2.8	8.09	2.3	9.36	2.3
13.	TGI Music, Art	5.97	2.7	6.20	2.6	7.05	2.7	8.49	2.9
14.	TGI History, Literature	6.93	2.7	7.38	2.7	7.49	2.5	8.90	2.8
15.	TGI Recreation, Entertainment	6.88	2.7	7.09	2.6	6.90	2.7	8.56	2.9
16.	TGI Government, Public Affairs	6.00	2.5	5.53	2.6	7.11	2.3	8.54	2.5

[1]Sequential Tests of Educational Progress
[2]School and College Ability Tests
[3]Tests of General Information

tanelli, 1975) and by inspection of the curves of the latent roots. Rotations to oblique simple structure were made by the Binormamin program (Kaiser and Dickman, 1959). In selected analyses, a second order factor was extracted from the intercorrelations of the first order factors, and factors in all orders were transformed into an orthogonal, hierarchical structure in accordance with the procedures described by Schmid and Leiman (1957). Use also was made of Procrustes rotations to identical target matrices to demonstrate dissimilarities in results.

Results

Latent Root Analysis

The latent roots for all groups for the first seven factors are presented in Table 2. Also in-

Table 2
Latent Roots of Four Groups at Four Grade Levels Compared to the Roots of Random Data Matrices

Group and Factor	Random Data	Grade 5	Grade 7	Grade 9	Grade 11
White Males					
1	.29	10.17	9.11	8.88	8.92
2	.23	.88	.78	.66	.62
3	.19	.13	.27	.24	.35
4	.16	.12	.23	.21	.23
5	.13	.06	.08	.06	.13
6	.10	.03	.03	.04	.04
7	.07	.01	.00	.02	.03
Black Males					
1	.68	8.43	6.99	7.50	7.73
2	.53	1.19	1.05	.86	.89
3	.43	.21	.41	.37	.39
4	.37	.17	.25	.31	.35
5	.30	.11	.17	.17	.25
6	.24	.09	.14	.11	.10
7	.17	.07	.05	.03	.06
White Females					
1	.27	9.41	8.86	8.53	8.84
2	.21	1.03	.82	.62	.50
3	.17	.16	.22	.21	.23
4	.15	.10	.10	.16	.18
5	.12	.06	.07	.05	.09
6	.09	.04	.03	.02	.01
7	.07	.02	.00	.01	.00
Black Females					
1	.59	8.77	8.10	8.36	8.23
2	.46	1.08	.81	.85	.59
3	.38	.19	.38	.23	.28
4	.32	.16	.23	.15	.20
5	.26	.14	.18	.10	.15
6	.20	.06	.12	.09	.05
7	.15	.03	.03	.03	.05

cluded are estimates of the latent roots of random data matrices of the same number of observations and the same number of variables as the original data matrices. These estimates were obtained by the procedure recommended by Montanelli and Humphreys (1976). This table contains the principal data base in support of the differentiation hypothesis.

When the two criteria for determining the number of factors to retain, rotate, and interpret were applied to the information in Table 2, the conclusions summarized in Table 3 resulted. This table records the number of factors decisions separately for parallel analysis and for breaks in the curve formed by the latent roots. Also included are the traces of the several matrices.

The parallel analysis criterion is highly objective since the number of factors is taken to be the number of latent roots from the data matrix that are larger than the accompanying latent roots for random data. Objective techniques, however, are subject to sampling error. In contrast, looking for breaks in the curve of latent roots is more subjective; other investigations might reach different decisions. Almost always there are several breaks of varying sizes, and such breaks occur regularly in latent roots extracted from random data matrices as well as those from matrices representing psychological measures.

The relative size of the traces of the matrices from group to group and from grade to grade reflect a small decrease in the size of the communality estimates, the squared multiple correlations, from grade 5 to the later grades. The factors added during the time period represented here are defined out of somewhat smaller communality estimates. The size of the standard deviations in the present data which are found in Table 1 are indirect but quite dependable indicants that there has been no appreciable reduction in reliabilities overall between the two extreme grade levels. Thus the differentiation probably does not involve a reduction in the size of the specific factors in the tests.

For all groups at the 5th grade level, two factors are indicated by both criteria. Beyond the

Table 3
Traces of the Correlation Matrices and Summary of the Number of Factors Indicated by Two Criteria

	Grade			
Group	5	7	9	11
White Males				
trace	10.82	9.80	9.42	9.55
parallel analysis	2	4	4	5
break	2	4	4	5
Black Males				
trace	9.58	8.19	8.44	8.98
parallel analysis	2	2	2	2
break	2	3	4	5
White Females				
trace	10.19	9.44	8.93	9.17
parallel analysis	2	3	4	4
break	2	3	4	5
Black Females				
trace	9.74	9.03	9.06	8.80
parallel analysis	2	3	2	2
break	2	3	3	5

5th grade, the number of factors indicated by the two criteria do not always agree, but both criteria support the differentiation hypothesis in the two white groups. For example, for white females three factors are indicated by both criteria in the 7th grade data and four in the 9th grade data. In the eleventh grade, however, parallel anaylsis still indicates four factors while the break in the curve of the latent roots calls for a five factor solution.

In spite of the differences between the two criteria the evidence for differentiation in the white groups is very good while only root inspection suggests differentiation in the black groups. There is only one reversal in the expected monotonicity and this is by a small margin in the 7th grade data for black females. The two criteria agree more closely in the two larger samples, as would be expected if a systematic tendency were indeed present. In the samples for white students there is only one discrepancy, in the 11th grade data for females. This is also by a very small margin, well within the sampling errors of the two criteria.

Supportive of the stability of these findings from the sampling point of view are the trends from grade to grade in the size of selected roots. If additional factors are to be defined from nearly constant communalities, early roots must decrease in size. In these data, the first and second roots decrease in size from grade 5 to 11 while the later roots increase in size during this time period. These trends are smoother, also, in the groups having the larger Ns.

Rotated Factor Patterns

It is interesting to trace the development of the five 11th grade factors from the two defined at the 5th grade, but there is too much data to do this for each of the four groups. Data for white males were selected because the latent roots for this sample showed the clearest differentiation. Table 4 presents oblique factor pattern loadings for this sample for each of the four time periods in the number of factors indicated by Table 3. In each case the most nearly equivalent factor at later time periods is paired with one for the earlier time periods.

At grade 5 the broader and more traditional aptitude and achievement tests appear on one factor and the narrower, less traditional information tests appear on the second. In an important sense, these are not methods factors although that is the natural initial response to the data. There appears to be instead an important difference in content. The contribution to variance of meanings of abstract words is higher in the STEP tests of achievement than in the TGI information tests. Factor I at grade 5 is recognizable as a more restricted verbal comprehension factor at grade 11, but a separate quantitative ability factor (Factor IV) is also defined in the latter grade. As a matter of fact, this difference appears at grade 7 and continues at grade 9 with the changes between grades 7 and 11 being in the clarity of the distinction.

In this case, an arbitrary decision to rotate three factors at grade 5 does allow the quantitative ability factor to appear, but it is less well defined than in grade 7. Since no sampling error differences are involved (the same boys are represented at all grade levels), the lack of good definition is itself evidence for the differentiation hypothesis.

Factor II at grade 5 differentiates into three separate factors with two of these appearing at grade 7 and the third at grade 11. The first two can be called feminine (II) and masculine (III) information, with the latter picking up one test, STEP Physical Science, from the 5th grade Factor I. The last of the 11th grade factors is defined by information tests of history, literature, government, and public affairs, which represent predominantly social science information. This factor also picks up one test from the 5th grade Factor I, STEP Social Science. An arbitrary decision to extract and rotate five factors at the 5th grade does not allow these factors to appear. This again adds credence to the differentiation hypothesis.

Although supporting tables cannot be presented here, a brief summary of similarities and differences in factor patterns in this sample and for white females and black males and females

Table 4

Differentiation of Oblique Factor Patterns in White Boys, Grades 5 - 11

	Tests	I				II				III			IV			V
		5	7	9	11	5	7	9	11	7	9	11	7	9	11	11
STEP-M	1	92	29	17	04	-07	03	-10	03	-06	12	-02	63	74	84	-05
STEP-PS	2	81	72	63	40	07	-31	-26	-13	34	42	45	14	10	10	06
STEP-SS	3	89	78	64	64	01	00	03	-20	01	13	05	14	15	06	36
STEP-R	4	86	85	98	94	04	-01	03	16	-07	-07	-02	11	-06	-09	-10
STEP-L	5	68	71	68	72	08	11	-05	-22	05	18	09	-02	01	-05	24
STEP-W	6	84	61	95	89	02	00	09	13	-09	-22	-17	35	02	15	-14
SCAT-V	7	58	61	53	48	35	23	28	21	10	21	08	01	-09	-01	21
SCAT-Q	8	88	03	-07	-02	-12	03	08	-05	-05	-05	05	81	87	85	02
TGI-IA	9	02	02	-07	-04	80	-03	-04	02	77	69	68	-09	02	01	-08
TGI-HA	10	-08	-06	01	08	84	35	48	70	25	15	06	10	00	-04	-09
TGI-PS,M	11	03	-14	08	-09	83	08	16	05	52	59	56	30	-06	07	22
TGI-BS	12	16	27	03	19	69	17	22	16	57	44	42	-18	-03	-11	09
TGI-M,A	13	07	-10	-03	-04	72	63	65	56	11	25	04	11	-13	-06	29
TGI-H,L	14	08	34	-06	06	76	77	75	15	-12	-04	-08	-20	14	01	67
TGI-R,E	15	-14	-13	19	-10	93	74	68	50	06	-08	-09	07	-07	18	30
TGI-G,PA	16	03	-04	-03	-02	75	72	63	-02	02	01	00	12	12	-04	80

can be added. This summary is based upon rotations of the same number of factors in each group at each grade level as for the white males. This was done on the hypothesis that sampling errors, particularly important in the two smaller groups, might have obscured the number of factors decisions.

Factors for the white females are poorly defined in grades 7 and 9, but become almost identical with those for the white males at grade 11. Thus, the rotated loadings support the comparison of the latent roots: namely, that factor differentiation is clearer in the white males. In the earlier grades only the quantitative factor is as well defined as in the white males, but the other factors are recognizable.

Factors for both black groups also are defined poorly and do not converge toward the white males at grade 11. Even the quantitative factor is defined poorly for black females at grade 7 and becomes poorly defined again at grade 11. The latter is presumably due to the extraction of too many factors for the number of observations that entered the correlations. There is also no evidence for the separation of masculine and feminine information factors at grade 7 for either sex, and the separation at grades 9 and 11 is unclear at best. For black males the TGI tests split into academic and nonacademic information with both industrial and home arts on the second factor. For black females industrial arts appears on an approximation to the feminine information factor at grade 9. Whether these discrepancies are due to the smaller Ns or to real differences in factor patterns for whites and blacks in the student population sampled by ETS is an important question.

Hierarchical Rotations

Table 4 in an important sense exaggerates the extent of factor differentiation. Loadings are large so that in the absence of factor intercorrelations, the additional factors reflecting learning and maturation appear to describe large amounts of variance. In place of reporting factor intercorrelations, however, it was decided to rotate factors in two orders to a hierarchical structure. Since only one second order factor provides a good fit to the first order correlations, a hierarchical rotation reveals a general factor and five group factors. The size of the group factors after such rotation reveals quite clearly the amount of variance that can be attributed to the new factors that appear.

Table 5 presents these rotations for 11th grade white males and females. The parallelism between the two sets of rotations is quite dramatic. Rotations were not modified by any judgmental process. The only judgment made was that the pattern of latent roots for females was close enough to the pattern for males to justify the retention and rotation of five factors in both cases. The largest differences in size of loadings of individual tests occur for the domestic arts. For these tests one might expect culturally reinforced sex differences in function, as well as in means. In accordance with expectations based upon the relative sizes of the latent roots, also, it appears that the factors for the males tend to be just a bit better defined than for the females. In this comparison, however, sampling error does enter the picture.

The difference is also dramatic in the amount of variance described by the general factor and the separate group factors, or for all of the group factors combined. While general factor loadings are somewhat smaller in the 11th grade, and particularly so in the narrow information tests, the general factor is still preeminent. While the evidence for factor differentiation appears to be sound, the amount of differentiation is quite limited.

Procrustes Rotations to the 11th Grade Target

It is also possible to show differences in factor patterns by attempting to maximize similarities. For the present data a target matrix was formed from the 11th grade hierarchical rotations for males and females, and this target was used for all groups at all grade levels. While it is easy to capitalize on chance in Procrustean rotations and thus exaggerate similarities, differences are

Table 5

Hierarchical Factor Loadings of Boys and Girls in Grade 11

	Tests	General Factor		I		II		III		IV		V	
		M	F	M	F	M	F	M	F	M	F	M	F
STEP-M	1	72	72	01	-02	01	-03	-01	01	44	37	-02	04
STEP-PS	2	77	74	14	08	-06	-16	25	18	05	03	02	08
STEP-SS	3	84	85	23	19	-08	-08	02	04	03	01	14	10
STEP-R	4	83	82	34	33	07	-03	-01	-02	-05	-04	-04	01
STEP-L	5	73	77	26	24	-09	-02	05	07	-03	04	09	-04
STEP-W	6	80	78	32	31	05	06	-09	-11	08	03	-06	01
SCAT-V	7	89	89	17	25	09	09	05	10	-01	-03	08	-06
SCAT-Q	8	72	69	-01	02	-02	03	03	-01	44	36	01	-03
TGI-IA	9	48	62	-01	-03	01	04	38	29	00	01	-03	-04
TGI-HA	10	64	66	03	-03	30	15	03	06	-02	03	-04	08
TGI-PS,M	11	70	64	-03	00	02	04	31	24	04	-01	09	00
TGI-BS	12	66	64	07	01	07	-03	23	19	-06	-05	04	08
TGI-M,A	13	72	75	-01	00	24	25	02	03	-03	-03	11	09
TGI-H,L	14	76	75	02	-02	07	10	-04	-02	01	-01	26	21
TGI-R,E	15	71	71	-04	04	21	26	-05	04	09	02	12	00
TGI-G,PA	16	67	64	-01	00	-01	00	00	-02	-02	01	32	21

all the more dramatic. That is, alpha errors are minimized when using a Procrustes rotation to demonstrate differences rather than similarities.

Again, excessive space would be required to present the data for all four groups, and therefore only the results for the white males will be reported. The general factor and the five group factors are shown in Table 6 for this sample for all grade levels. Factors are numbered to parallel those in Table 5.

The factors are certainly similar to each other at all grade levels. If four independent samples had been used in a cross-sectional design, it would have been difficult to oppose a sampling error explanation for differences. With minimal sampling error differences from grade 5 to grade 11, however, the interpretation is quite different. There is a gradual sharpening of the factor pattern during the six year period. Large loadings tend to become larger and small loadings smaller with increasing age on the group factors while the size of the loadings on the general factor become somewhat smaller.

It must be emphasized that Procrustes rotations do capitalize upon chance to a marked degree. Similarities between factors at the several grade levels have been forced by the methodology. Differences are truly larger than what they seem. There is much less similarity, for example, when five factors are extracted at each grade level and rotated independently to simple structure by the Binormamin program. If one

Table 6

Hierarchical Factor Loadings for Boys in Grades 5 - 11

After Rotation to a Common Target Matrix

	Test	General Factor				I				II			
		5	7	9	11	5	7	9	11	5	7	9	11
STEP-M	1	73	73	73	67	29	31	27	22	-04	-01	-06	01
STEP-PS	2	74	70	72	70	37	40	35	26	-01	-04	-07	00
STEP-SS	3	76	76	78	76	42	45	39	41*	-03	-05	04	-01
STEP-R	4	75	71	74	73	49	53	49	47*	02	06	06	11
STEP-L	5	64	71	68	65	34	37	36	40*	-08	-05	-03	-03
STEP-W	6	72	71	70	72	46	46	49	48*	12	08	09	07
SCAT-V	7	79	78	80	81	36	37	32	33*	14	11	21	17
SCAT-Q	8	67	67	66	68	28	22	19	20	-03	04	-06	-02
TGI-IA	9	71	53	49	44	08	-01	04	01	23	13	11	05
TGI-HA	10	67	54	55	59	00	05	10	11	22	21	26	35*
TGI-PS,M	11	76	60	64	65	07	02	12	07	29	17	14	11
TGI-BS	12	73	67	54	60	13	11	09	14	15	13	17	15
TGI-M,A	13	68	64	64	67	12	05	08	11	27	27	30	33*
TGI-H,L	14	73	69	68	71	11	21	12	20	22	20	23	18
TGI-R,E	15	70	64	63	66	05	05	18	11	34	34	25	29*
TGI-G,PA	16	70	71	63	63	10	07	11	16	24	22	18	12

Table 6 continued

	Test	III				IV				V			
		5	7	9	11	5	7	9	11	5	7	9	11
STEP-M	1	12	05	09	02	37	35	43	46*	-01	02	00	-03
STEP-PS	2	25	27	28	32*	17	12	12	10	-05	-04	04	02
STEP-SS	3	13	12	15	10	18	15	15	10	06	09	06	16
STEP-R	4	11	06	08	10	09	09	09	05	04	-03	03	00
STEP-L	5	20	14	18	12	09	07	06	05	09	18	11	11
STEP-W	6	05	04	-01	01	14	19	14	18	-05	-07	00	-02
SCAT-V	7	15	16	20	15	07	03	02	04	08	10	04	11
SCAT-Q	8	04	03	-01	05	36	41	46	46*	01	-04	06	-01
TGI-IA	9	35	43	36	42*	-03	-06	01	00	08	04	-03	-0[illegible]
TGI-HA	10	27	17	12	15	00	02	01	-03	18	08	06	01
TGI-PS,M	11	26	30	35	37*	03	11	-04	02	12	00	08	08
TGI-BS	12	34	37	26	32*	00	-08	-01	-05	11	14	04	05
TGI-M,A	13	23	12	19	13	-02	03	-09	-05	08	18	16	15
TGI-H,L	14	15	05	05	04	00	-07	04	00	24	31	24	29*
TGI-R,E	15	16	09	05	04	-05	-01	-04	07	21	17	20	15
TGI-G,PA	16	10	09	07	06	00	06	03	-04	26	26	23	33*

* Target equals unity for orthogonal Procrustes rotations for those measures at all grade levels for the group factor indicated; target equals zero for all other measures for the factor; all measures had target of unity in the general factor.

were concerned primarily with beta errors, the latter rotations would be more appropriate.

Discussion

The breadth of cognitive information and skills sampled by the present tests is quite restricted, and the factors cover only a small number of the Thurstone Primary Mental Abilities. Thus, generalization is limited. A critic might argue that factor differentiation occurs in information tests solely as a function of opportunity for specialization in learning and that the Thurstone primaries are very different. The present writers would accept the first part of the preceding statement but not necessarily the second. One of us has described differences among intelligence, aptitude, and achievement tests along three quantitative dimensions (Humphreys, 1962) and concluded that there are no qualitative differences of the sort usually associated with the names used to describe the several different tests. Humphreys (1974) has also concluded that there are no differences in degree of heritability among most aptitude and information tests, with only the spatial visualization tests being somewhat questionable. Thus, it can be argued that the use of an appropriate methodology at appropriate age levels might also show

factor differentiation for tests like the Thurstone primaries. This differentiation would also depend on opportunities for specialization. Since the differentiation, if it occurs, would be gradual and small in amount, even over rather extended time periods, use of a repeated measures design would be almost essential.

Although generalization to a wider sample of tests is precluded, generalization to a wider age range is more reasonable. It is highly probable that differentiation among academic information tests would proceed at an accelerated rate beyond the high school years. There is near zero academic specialization possible during the grade school period. Such specialization gradually increases in junior high and high school and proceeds at an accelerated rate in college. There should be further differentiation of factors in a large battery of cognitive tests administered to college seniors.

Early specialization tends to occur extracurricularly. Pressures to assume sex roles are probably among the most important influences leading to the differential growth of interests, knowledge, and skills. In white males the differentiation of masculine and feminine information that is discernible in Ns of the size used here occurs between the 5th and 7th grades and becomes increasingly sharper between the 7th and 11th grades. This differentiation seems to occur with less sharpness in white females although this conclusion remains uncertain as a function of the relatively large sampling errors in the matrices of intercorrelations of the measures. While the Ns used here are considerably larger than those that appear commonly in the factor analytic literature, it is illuminating to place confidence intervals around correlations based upon as many as 700 observations.

Differences between black and white samples in these data are intriguing, but conclusions should await more definitive analyses based upon larger samples. Is there less factor differentiation in black children and adolescents than in whites? Are the factors that are defined similar or different? Or are the seeming differences due entirely to the use of Ns of radically different sizes? A partial answer to the last question has been obtained by repeating the white analyses with random samples of white males and females of the same size as the black samples. The evidence for clear factor differentiation with increase in grade and age disappears in these analyses. Repetition of the black analyses in grade 11 with a much larger N is possible with present data and is planned for the immediate future.

While no explicit analysis of the size of specific factors at the several grade and age levels represented here was possible in the absence of accurate reliability estimates in these samples, the data indicate no reduction in the size of specific factors with increasing education and age. Communalities tend to be lower in the 11th than in the 5th grade by a small amount, and the indirect evidence concerning reliability indicates no appreciable reduction overall. Under these circumstances the hypothesis that common factor differentiation accompanies a *decrease* in size of 5th grade specifics can be rejected with considerable confidence. If 11th grade reliabilities were appreciably higher than those in the 5th grade, however, common factor differentiation would be accompanied by *increases* in the size of specifics. Since the distinction between a specific and a common factor is mathematical rather than psychological, depending upon the initial selection of measures to be administered and intercorrelated, one can expect factor differentiation to be in the specifics in some batteries of tests, in the common factors in others, and in both common and specific factors in still others. One can also expect that differentiation will be gradual and small in amount even over rather extended time periods. The general factor makes, by far, the largest contribution to variance at all grade levels.

References

Anastasi, A. *Differential Psychology.* The Macmillan Company, New York, 1958.

Anastasi, A. On the formation of psychological traits. *American Psychologist,* 1970, *25,* 899-910.

Fitzgerald, J., Nesselroade, J., & Baltes, P. Emergence of adult intellectual structure: prior to or

during adolescence? *Developmental Psychology,* 1973, *9,* 114-119.

Hilton, T. L., Beaton, A. E., & Bower, C. P. Stability and instability in academic growth—a compilation of longitudinal data. Final Report, ETS, August 1971.

Humphreys, L. G. The nature and organization of human abilities. *19th Yearbook of the National Council on Measurement in Education,* 1962, 39-45.

Humphreys, L. G. Number of cases and number of factors: an example where N is very large. *Educational and Psychological Measurement,* 1964, *24,* 457-466.

Humphreys, L. G. The misleading distinction between aptitude and achievement tests. *The Aptitude-Achievement Distinction,* D. R. Green (Ed.). Monterey, California, CTB/McGraw-Hill, 1974, 262-274.

Humphreys, L. G., & Ilgen, D. R. Note on a criterion for the number of common factors. *Educational and Psychological Measurement,* 1969, *29,* 571-578.

Humphreys, L. G., & Montanelli, R. G. An investigation of the parallel analysis criterion for determining the number of common factors. *Multivariate Behavioral Research,* 1975, *10,* 193-206.

Kaiser, H. F., & Dickman, K. W. Analytic determination of common factors. *American Psychologist,* 1959, *14,* 425. (Abstract)

Montanelli, R. G., & Humphreys, L. G. Latent roots of random data correlation matrices with squared multiple correlations on the diagonal: a Monte Carlo study. *Psychometrika,* to appear 1976.

Reinert, G. Comparative factor analytic studies of intelligence throughout the human life-span. *Life-span Developmental Psychology: Research and Theory,* L. R. Goulet & P. B. Baltes (Eds.). New York, Academic Press, 1970.

Schmid, J., & Leiman, J. The development of hierarchical factor solutions. *Psychometrika,* 1957, *22,* 53-61.

Acknowledgements

This research was supported by a grant from the National Institute of Mental Health, MH 23612-02, Prediction of Advanced Academic Performance. We thank Dr. Thomas L. Hilton and Educational Testing Service for providing data from the Study of Academic Growth and Prediction (the Growth Study). Authors are listed in alphabetical order.

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