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A FACTOR ANALYTIC STUDY OF THE STANFORD BINET WITH YOUNG CHILDREN

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Summary: Seven factors were found as the result of a factor analysis of year IV-6 through year VI of the 1960 Revision of the Stanford Binet Intelligence Test. No factor had a sufficient number of high loadings to justify interpretation as 'g,' a general intelligence factor. The test protocols used were of 152 children from three to seven years of age who attended a University nursery school or Head Start day care centers. The group included 107 white and 45 Negro children who had been tested as part of a routine intellectual evaluation. The socioeconomic level, as measured by occupation of the parent, was higher than that of the standardizing population of the Binet, as was the mean IQ (109.4 ± 14.7). The results of this study were compared with the logical analysis of Meeker & Bonsall based upon Guilford's factors of the intellect, and with Valett's profile analysis.

Almost all school and clinical psychologists utilize some form of subtest analysis when evaluating individual intelligence test results. If the Wechsler Scales were used, the psychologist may rely upon the factors outlined in factor analytic studies reported by Wechsler and others. If the 1960 revision of the Stanford Binet was given, the psychologist usually has to rely on logical analysis. Only one factor analytic study has been done with the 1960 revision (Stormer, 1967); it only involved 14 year olds, and, in addition to the Stanford Binet, other tests were utilized in the analysis.

Systems of subtest analysis have not been encouraged by Terman & Merrill (1960), authors of the Revised Binet. In discussing the test, they stated that

> the very factors that contribute to its success as a measure of general intelligence must interfere with its usefulness as a measure of the various separate aspects of mentality. . . grouping tests together according to some logical classification scheme on the basis of some special ability which they appear to have in common has little psychological justification [pp. 12-13].

The authors indicated, however, that

> McNemar's factorial analysis of the items making up the L and M scales has furnished the most comprehensive study of the intellective functions which the scale measures. His findings support the view that a single common factor could explain performance on the Stanford Binet [pp. 34-35].

The authors admit, however, that "this does not exclude the possibility that group factors may be present at some age levels" [p. 35].

Despite the position taken by Terman & Merrill (1960)), two methods of logical analysis of the Binet have been developed, one by Meeker & Bonsall (1960) and the other by Valett (1963-64). Meeker & Bonsall's method is based upon the 120 factors identified by Guilford (1956), who stated that each intellectual component is a unique ability that can be classified on the basis of the kind of operation performed and the type of content and product involved. Meeker & Bonsall analyzed each item of the Binet and categorized it according to Guilford's structure by assigning to it one or more trigraphs. "For convenience and preciseness in communication, each type of operation, content, and product is represented by a capital letter, thereby enabling one to designate each factor by a trigraph" [Newland & Meeker, 1963-64, p. 57]. Meeker & Bonsall found that certain items involved only one of Guilford's factors while others involved primarily one factor and secondarily one or more factors. That the authors were aware that their logical analysis must be supplemented by other evidence is indicated in a later article by Newland & Meeker (1963-64):

> The accuracy with which each item is characterized in terms of Guilford's factors must be established . . . Two possibilities suggest

themselves here: (*a*) either correlating performance on each item with performance on the tests initially used in the identification of the factors involved or (*b*) perhaps better, making a factor analysis of performance on Binet items to see if those factors emerge which were judgmentally determined to be involved [p. 59].

Stormer (1967) did not feel his results supported the establishment of Guilford's factors: "The operations categories of Meeker and Bonsall are not validated" [p. 115].

Valett (1963-64) arrived at the construction of his individual profile form for the analysis of the Binet in a different manner:

Following a consideration of the various factors of intellect as proposed by Binet (1916), Thurstone (1938) and Guilford (1959) among others, the following item classifications were made: sensory and perceptual discrimination, comprehension, motor coordination, judgment, comparisons, imagery, vocabulary, memory, arithmetic reasoning and speed of response. Six credentialed and experienced psychological examiners then proceeded to classify each item and the degree of agreement and disagreement was discussed [p. 49].

Six categories were agreed upon: General Comprehension, Visual Motor Ability, Arithmetic Reasoning, Memory and Concentration, Vocabulary and Verbal Fluency, and Judgment and Reasoning.

METHOD

The present study used the Stanford Binet, 1960 Revision, test results of 152 children from three to seven years old with an average age of four and one-half years. The importance of this age group is highlighted by recent emphasis on research in learning with young children. The age range is a restricted one, but necessarily so. The structure of the Binet is such that the majority of items change markedly from one age level to the next, so that older or younger children would not be given the items of the present study even if the Binet was administered to them. The test protocols were drawn from a larger group of 227 that had been obtained as part of a routine intellectual evaluation carried out in the Hofstra Nursery school and six Head Start day care centers. The 152 tests were selected on the basis of having at least four passes and four failures out of a group of 18 items in the range from year IV-6 through year VI. Thus older children who might have failed only one item in this age range and younger children who might have passed only one item in this range were excluded. To have included such children would have resulted in spuriously high correlations between subtest items.

The IQs of the group ranged from 76 to 157 with a mean of 109.4 ± 14.7. There were 107 white and 45 Negro children (85 boys and 67 girls). The socioeconomic level of the group, as measured by parent's occupation, was higher than that of the population upon which the Binet was standardized, and the sample, therefore, is not representative. There were 48% with parents in the white collar class compared to 37% in the general population as indicated by U.S. Census figures for 1960.

The raw data were converted to a correlation matrix of tetrachoric correlations by a program obtained from the Institute of Behavior Science (Castellan, 1964). The program was adapted to the IBM 1130 for use at the Hofstra University Computer Center. The correlation matrix was subjected to a principal components analysis and a varimax rotation as provided by the IBM 1130 Statistical Package. Guttman's criterion (Kaiser, 1960) of extracting all factors whose eigen-values are greater than one was employed.

RESULTS

As the result of the principal components analysis, a first factor was extracted on which 12 out of the 18 subtests appeared. These subtests and their loadings were: Materials +.88; Opposite analogies II +.80; Vocabulary +.75; Differences +.70; Mazes

Table 1
Rotated Loadings of Stanford-Binet Subtest Items

Year		Item	Factors I	II	III	IV	V	VI	VII
IV-6	1	Aesthetic Comparisons	.07	.84	.05	-.04	-.12	-.14	.09
IV-6	2	Opposite Analogies I	.80	-.02	-.12	.17	.05	-.08	-.08
IV-6	3	Pictorial Similarities & Differences I	.21	.11	.15	.87	.18	-.13	.07
IV-6	4	Materials	.93	.03	.06	-.09	.22	.07	.19
IV-6	5	Three Commissions	-.02	-.05	.07	-.12	.01	.88	-.02
IV-6	6	Comprehension III	.54	.19	.12	-.68	.24	.22	.18
V	1	Picture Completion: Man	.44	-.06	-.11	.25	.00	.25	.41
V	2	Paper Folding: Triangle	-.24	.73	-.01	.08	.15	.10	-.10
V	3	Definitions	-.17	-.17	-.55	-.52	.14	-.25	.38
V	4	Copying a Square	.05	.45	-.29	.34	.11	.26	.55
V	5	Pictorial Similarities & Differences II	-.07	.07	.20	.00	.63	-.19	.42
V	6	Patience: Rectangles	-.08	-.05	.87	.05	-.02	.03	-.01
VI	1	Vocabulary	.52	-.13	-.22	.07	.65	-.18	-.05
VI	2	Differences	.38	-.14	-.22	.07	.40	-.31	.46
VI	3	Mutilated Pictures	.18	.03	.01	-.16	.16	-.05	.82
VI	4	Number Concepts	.19	.01	-.02	.02	.82	.36	.08
VI	5	Opposite Analogies II	.88	-.07	.04	-.02	.15	-.01	.21
VI	6	Maze Tracing	.31	.43	-.19	.01	.55	-.09	.17

+.64; Opposite analogies I +.60; Number concepts +.60; Comprehension III +.59; Mutilated pictures +.54; Drawing man +.50; Pictorial similarities and differences +.42; and Drawing square +.38. Six additional factors were extracted. Only loadings with absolute values of .30 or higher were considered in identifying the factors. Of the six additional factors, all were bipolar and contained from four to seven subtests per factor. Because of the bipolar nature, the factors were difficult to interpret.

To facilitate interpretation, all the factors were rotated by the varimax method which gives a solution approximately equivalent to Thurstone's "simple structure" (1935, pp. 150-163). As the result of the varimax rotation seven factors were found. Table 1 indicates the loadings of each subtest item on each of the factors. Table 2 contains the seven factors and the items loading on each of these as well as the six categories developed by Valett (1963-64) and the trigraphs assigned to each subtest by Meeker & Bonsall (1960). Table 3 shows Guilford's Dimensions of Intellect from which the trigraphs were derived.

DISCUSSION

The principal components solution is of such a nature that it extracts the maximum amount of variance for the first factor, and therefore offers the best opportunity to find a general intelligence or common factor. The first factor found in the present principal components solution does not satisfy the usual definition of "g" or a common factor, by having all the variables load heavily on it. The fact that only two thirds of the 18 subtest items loaded on this factor and that six other factors, with a substantial number of subtests loaded on them, were found suggests that the Binet in this age range cannot be explained in terms of a single common factor. A consideration of the group factors found through the varimax rotation seems worthwhile, and the following discussion relates to those factors.

As can be seen in Table 2, the items that load on Factor I appear to be verbal in nature with the exception of Maze Tracing and Picture Completion: Man. Although both of these subtests appear to involve visual motor coordination, the fact that they show a verbal component is not surprising be-

Table 2

Seven Factors of Present Study and Their Relation to Guilford's Factors and Valett's Categories

Factor I	Factor II	Factor III	Factor IV	Factor V	Factor VI	Factor VII	Valett
Matrls .93 CMI,CMT							General Comprehension
Comprhn .54 CMI,CMT							
Man .44[a] CFI,CFU,NFI	P.Foldng .73 CFT,NFR	Rectgls .87 CFS,CFT	Square .34[a] EFS,NFU	Mazes .55[a] CFI		Square .55[a] EFS,NFU	Visual Motor
Mazes .31[a] CFI	Square .45[a] EFS,NFU					Man .41[a] CFI,CFU,NFI	
	Mazes .45[a] CFI						
				Numbrs .82[a] MSI,NMR	Numbrs .36[a] MSI,NMR		Arithmetic Reasoning
					3 Comm. .88 MMR		Memory, Concentration
Vocab. .52[a] CMU				Vocab. .65[a] CMU		Defntns .38 CMI,CMT	Vocabulary, Verb.Fluency
Anals 2 .88 CMR,EMR	Es.Comp. .84 EMR,EFS	Rectgls .87 CFS,CFT	Sim.Dif.1 .87 CFC,CMC,EFU	Sim.Dif .2 .63[a] CFC,EFU		Mut.Pic. .82 CFU,MSI	Judgment Reasoning
Anals 1 .80 CMR,NMR,IMS				Diffncs .40[a] CMT,IMI,CFI		Diffncs .46[a] CMT,IMI,CFI	
Diffncs .38[a] CMT,DMI,CFI				NMC		NMC	
NMC						Sim.Dif.2 .42[a] CFU,EFU	

Note: Each column contains abbreviated names for all items with loadings of more than .30 in absolute value on the factor named at the head of the column. Each row contains the items which are included in the Valett category named at the extreme right. Three letter codes identify factors from Guilford's three-dimensional model as suggested by Meeker & Bonsall, and are placed immediately below items in which the factor should appear.

[a] Items that load on more than one factor.

Table 3

Guilford's Three Dimensions of Intellect

Operations	Contents	Products
C—Cognitive	F—Figural	U—Units
M—Memory	S—Symbolic	C—Classes
D—Divergent Thinking	M—Semantic	R—Relations
N—Convergent Thinking	B—Behavioral	S—Systems
E—Evaluation		T—Transformation
		I—Implications

cause to be successful with these subtests, verbal instructions must be understood. A subtest that does not appear, which might be expected to load on this factor, is Definitions. This subtest involves defining three words: ball, hat, and stove. It apparently depends on aspects other than those sampled by Factor I. It is of interest that Meeker & Bonsall (1960) assigned every item on Factor I a trigraph which involves a cognitive operation, and those subtests which load most heavily on Factor I (Materials, Comprehension, Vocabulary, and Opposite Analogies) all have been assigned a semantic content. It would appear that Factor I samples that aspect of intellect that is dependent upon cognitive semantic (CM) functioning, and the operation involved appears to be the most important determinant with the content secondary and the product relatively peripheral.

The subtests which load on Factor II all seem to involve visual or visual motor ability. All have trigraphs which include figural content. In Guilford's terms, figural items involve concrete material perceived through the senses, and this seems to be the primary component of the subtests involved in Factor II. The type of operation and product appear to be less important.

Factor III consists of only one subtest, Patience Rectangles, which is not measured to any extent by any other factor included in this analysis. Patience Rectangles has somewhat unstructured directions and a puzzle like nature, which may result in persistence and/or chance playing a role in its success. Meeker & Bonsall assigned two different trigraphs to this subtest, CFS (cognitive figural systems) and CFT (cognitive figural transformations). Because this item does not seem related to any other subtest, its classification as CFS seems more logical, if CFT is considered to identify the subtest Paper Folding.

The items loading on Factor IV appear to involve visual ability and judgment, which might well fit in with Meeker & Bonsall's trigraph EFU (evaluation of figural units).

A variety of subtests load on Factor V, all of which seem to measure some aspect of general knowledge. Too many of them have low loadings, however, to consider this a 'g' type factor. The trigraphs assigned to the items in this Factor show no common trend. It is possible that this is related to the fact that these subtests are complexly determined, for each loads on at least one other factor.

The two subtests loading on Factor VI seem to involve control of impulsivity. Meeker & Bonsall assigned trigraphs emphasizing memory, but whether this is the major operation is questionable in view of the fact that Number Concepts involves long term memory, whereas Three Commissions involves short term attention. The Three Commissions subtest, which has the heavier loading on this factor (.88)

and loads on no other, depends to a considerable degree on behavioral control and attention. Success on Number Concepts, even when a child has a knowledge of counting, depends on attending to the number of blocks to be counted and controlling the tendency to continue adding blocks beyond the required number. It is possible that this factor is more dependent upon a cognitive behavioral aspect of intelligence than upon memory.

On Factor VII, all items but two (Definitions and Differences) seem to require visualization: unless one can see the items they cannot be done. A visual nature might also be attributed to Definitions and Differences, in that the child may utilize visualization on tasks such as explaining the meaning of the word ball or the differences between a bird and a dog. This seems to be stretching the logic, however. The trigraphs assigned by Meeker & Bonsall vary, but all except those assigned to Copying a Square involve cognitive operations. It is possible that this factor depends on visualization and cognition and that the content and product aspect of the subtests is unimportant.

Table 2 indicates that there is little agreement between the seven factors found in this study and the profile divisions developed by Valett. There is agreement with respect to the subtest Three Commissions, classified by Valett as tapping memory and concentration. This seems similar to the behavioral control and attention mentioned previously as appearing to assess the functions associated with this subtest item. The two subtests Valett classified under General Comprehension appear as part of Factor I, considered to measure cognitive semantic functioning. This might be another way of saying general comprehension. The subtests classified in Valett's Visual Motor category and in the Judgment and Reasoning category load on six different factors. Although Valett's Vocabulary and Verbal Fluency category contains only two items, they load on three different factors. The seven factors found in this study suggest that the subtests of the Binet are more complexly determined and of a somewhat different structure than the Valett outline would indicate. The use of Valett's profile to analyze a child's functioning on the Binet may be misleading, because it suggests that performance on each subtest item depends on only one aspect of intelligence. The results of the present study do not support that position.

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