# AN EMPIRICAL INVESTIGATION OF THE BEHAVIORAL DIMENSIONS OF FOUR TESTS OF LEARNING DISABILITIES

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This is to certify that the

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ABSTRACT

AN EMPIRICAL INVESTIGATION OF THE BEHAVIORAL DIMENSIONS OF FOUR TESTS OF LEARNING DISABILITIES

By

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Diagnosis of learning disabilities in children requires the use of a number of time-consuming individually administered tests. These tests are based upon tasks designed by the author to conform to the test's theoretical dimensions or factors, but these factors are often inconsistent with empirical data. The major objective of the present study was to identify the dimensions which underlie four tests used for the diagnosis and remediation of learning disabilities. The tests used in this study were: the Illinois Test of Psycholinguistic Abilities, Revised Edition (ITPA); the Marianne Frostig Developmental Test of Visual Perception (DTVP); the Wepman Auditory Discrimination Test (WADT); and the Purdue Perceptual Motor Survey (PPMS).

A theoretical framework for hypothesizing a factor structure for this test battery came from Guilford's Structure of Intellect Model and his Matrix of Psychomotor Abilities. Sixteen dimensions were hypothesized to explain the factorial composition of the 28 sub-tests in the test battery.

Data collected from 305 disadvantaged kindergarten children were submitted to Principal Axis Factor Analysis with Varimax Rotation. The resulting factor analyses were interpreted for

a Four-Test Battery on 93 Ss, a Three-Test Battery (excluding the PPMS) on 305 Ss, and each test for 305 Ss. In addition, a Two-Way Analysis of Variance and Multiple Regression Analyses were done, the former to determine the extent to which experimental controls for age and sex were present in this study, and the latter to identify a set of sub-test variables that predict I.Q.

The results showed the factorial nature of this battery of tests was best represented by nine dimensions described by Guilford. These were: (a) Cognition of Sematic Relations (CMR); (b) Convergent Production of Semantic Relations (NMR); (c) Memory for Symbolic Systems (MSS); (d) Cognition of Figural Systems (CFS); (e) Evaluation of Symbolic Units (ESU); (f) Trunk Strength and Limb Flexibility; (g) Limb Impulsion and Gross Coordination; (h) Limb and Gross Precision; and (i) Memory for Figural Units (MFU).

The factorial nature of the individual tests in the battery is best explained as follows: (a) the ITPA is represented by the first three dimensions above; (b) the DTVP is represented by the fourth dimension listed above; (c) the WADT is represented by the fifth dimension above, and (d) the PPMS is represented by the remaining four dimensions given above.

The nine sub-tests of this battery most highly associated with nine factors were, respectively: (a) Visual Reception; (b) Verbal Expression; (c) Auditory Sequential Memory; (d) Spatial Relations; (e) the WADT; (f) Angels-in-the-Snow; (g) Jumping; (h) Identification of Body Parts; and (i) Chalkboard.

These nine sub-tests should provide the same factorial data the entire battery would when administered to disadvantaged Ss. Also, these sub-tests appear to reduce significantly the time needed to gather data representative of the battery's factorial nature.

A comparison of the hypotheses and the empirical data resulted in the confirmation of one hypothesis. Confirmation was determined by the degree of congruence between the variables predicted to associate with a hypothetical factor, and those associated with its empirically determined counterpart. However, the empirical factor structure had its associated variables loaded with the empirical factors in a manner which demonstrated a psychologically meaningful relationship. These results seemed to mitigate the overprediction that resulted in the hypothetical factor structure.

The results of the Two-Way Analysis of Variance showed significant F-Ratios for age and sex on two factors. Age appeared to affect the results of the DTVP testing when the Ss were twelve months apart in age. Main effects resulted for sex and age on the factor loaded by the ITPA's reception, association, and closure sub-tests. Males and females differed significantly on those variables, and as age increased the Ss' scores increased.

It was shown that four sub-tests seemed to predict I.Q. better than all others. These sub-tests were: (a) Auditory Association, (b) Auditory Sequential Memory, (c) Grammatic Closure, and (d) Spatial Relations.

The results of this investigation led to the conclusion that a factorial model of the intellectual and psychomotor abilities present in disadvantaged Ss probably should contain at least six intellectual abilities and three psychomotor abilities. While the emphasis of this study is on the structure of the tests, it also appears possible that the disadvantaged Ss do not attain the ability skills necessary to adequately differentiate the underlying dimensions of this battery of four tests. Furthermore, the results suggested that a different model of ability dimensions may exist for the disadvantaged Ss.

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# DEDICATION

This study, such as it is, is fondly dedicated to my mother, who did not see its completion, but who was always sure I would finish what I set out to do.

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I would like to thank my dissertation committee chairman, Dr. Clessen Martin, for the help he gave me in completing this study. I would also like to thank the members of my committee: Dr. William Hicks, Dr. John Jordan, Dr. Jean LePere, and Dr. Ruth Brend. Especial thanks go to the "Little Mother" of Special Education doctoral students, Mrs. Vivian Stevenson, for smoothing the rough road a doctoral candidate travels. Dr. Jane Bonnell and Mrs. Joan Webster provided immeasurable service in resolving problems during the data collection in the Grand Rapids Public Schools. To Mr. Robert Cross, who helped to recruit my examiners, and to Dr. Frank Heger, who trained them and otherwise gave wise counsel, I give thanks. The 13 examiners who did the testing deserve my gratitude because this study would not have been completed without them. And to my two sounding boards for wild ideas and wise advice, Drs. William Lashbrook and Joseph Ascroft, go special thanks for seeing my foibles and follies and protecting me from them. My typists, Mrs. Carole Winely and Mrs. Joan Lingle, who read rough copy beautifully and type rapidly, were gems. And, to the two secretaries, in the Grand Rapids Public Schools, Mrs. Helen Cameron and Miss Jean Brown, go my profoundest thanks for the thousand phone calls received and made to keep my study on its schedule. To Burt Rodee, who suffered and commisserated with me during our years together as graduate students, goes thanks for many timely and needed favors. Nearly last and certainly not least, I owe much to the patience and forebearance of my family; my wife, Rae, and my children, Steven and Trisa, during the graduate grind. Everyone, who has had this experience, knows that without the support of his immediate family, a doctoral student would not be able to complete the degree. Grateful thanks to all these persons is little enough for the benefits derived by me from having known all these friendly dedicated people.

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CHAPTER I

PROBLEM STATEMENT

What are the factors which underlie four of the major diagnostic tests of learning disability? Presumably, each of the theoretically derived sub-tests represents a distinct dimension. The major question of the present study is: would an empirical analysis of the data obtained through administering these tests support such an assumption? An examination of the recent history of the learning disability movement in education discloses many divergent theories (Bateman, 1966) concerning the diagnosis and remediation of learning disability. These theories have given rise to numerous measures such as the Illinois Test of Psycholinguistic Abilities (ITPA), the Marianne Frostig Developmental Test of Visual Perception (DTVP), the Wepman Auditory Discrimination Test (WADT), and the Purdue Perceptual Motor Survey (PPMS). These tests of learning disabilities present a variety of tasks assumed to be of diagnostic and remedial value. The tasks often do not factor according to the theory underlying them when subjected to a rigorous analysis. That they do not is supported by considerable evidence: Meyers, 1968; Sprague, 1963; Hueftle, 1967; Thams, 1955; and others. This lack of congruity between hypothesized dimensions and empirical dimensions represents a crucial failure in test validity.

The major purpose of this investigation was to establish the dimensions which underlie a battery of four tests of learning disability. These dimensions permit parsimonious description of the abilities assessed by the battery. In addition, their identification assures the selection of the smallest possible set of tasks which will yield data comparable to that obtained by the present battery. An analysis of the items comprising the factors found as a result of the present study may be used as a model for a comprehensive test for learning disabilities.

Before stating the a priori hypotheses regarding the manner in which the tasks were predicted to cluster, a description of the tests and a research review are necessary. The former provides prima facie evidence and the latter empirical substantiation for the rationale supporting these a priori hypotheses.

## Test Description

### The Illinois Test of Psycholinguistic Abilities (ITPA) (See Figure 1)

The Illinois Test of Psycholinguistic Abilities (ITPA) developed by McCarthy and Kirk (1961) provides information about a child's psycholinguistic capabilities. Psycholinguistic deficiencies found by this diagnostic battery become the basis of a specific remedial program for the child. Currently the authors have developed tests for ten psycholinguistic abilities (Kirk, McCarthy, and Kirk, 1968). These tests, based upon a theoretical model proposed by the authors

Sub-test Nomenclature

| | Revised Edition (1969) | Experimental Edition (1961) |
|---|---|---|
| 1. | Auditory Reception | Auditory Decoding |
| 2. | Visual Reception | Visual Decoding |
| 3. | Visual Sequential Memory | Visual Motor Sequencing |
| 4. | Auditory Association | Auditory Vocal Association |
| 5. | Auditory Sequential Memory | Auditory Vocal Sequencing |
| 6. | Visual Association | Visual Motor Association |
| 7. | Visual Closure[a] | |
| 8. | Verbal Expression | Vocal Encoding |
| 9. | Grammatic Closure | Auditory Vocal Automatic |
| 10. | Manual Expression | Motor Encoding |

Figure 1. Changes in Sub-test Nomenclature for the Revised Edition of the ITPA

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Note - In the research review, this writer changed the sub-test names to conform with the new nomenclature.

[a]A new test added to the Revised Edition.

(see Figure 2), are derived from Osgood's elaborated extension of Hull's formulations regarding psycholinguistic abilities. Each psycholinguistic ability, proposed by Kirk, has three dimensions, derived from the theoretical model, which are as follows:

> 1. *Channels of Communication.* These are the routes through which the content of communication flows. Included here are the modalities through which sense impressions are received and the forms of expression through which a response is made. The channels may include various combinations of sensory input and response output. The major modes of input are auditory and visual; those of output are vocal and motor.
>
> 2. *Psycholinguistic Processes.* In analyzing behavior which occurs in the acquisition and use of language, three main processes are considered: (a) the receptive process, that is, that ability necessary to recognize and/or understand what is seen or heard; (b) the expressive process, that is, those skills necessary to express ideas or to respond either vocally or by gesture or movement; (c) an organizing process which involves the internal manipulation of percepts, concepts, and linguistic symbols.
>
> 3. *Levels of Organization.* The degree to which habits of communication are organized within the individual determines the level of functioning. Two levels are postulated in the clinical model of the ITPA: (a) the representational level, which requires the more complex mediating process of utilizing symbols which carry the meaning of an object; (b) the automatic level, in which the individual's habits of functioning are less voluntary but highly organized and integrated. (Kirk, McCarthy, and Kirk, 1968. Page 7.)

The ten tests used in the ITPA are not an exhaustive set of psycholinguistic abilities. Kirk and McCarthy indicated that the testing of some abilities will have to await development of suitable task techniques (1961; page 7). This observation was confirmed by the revised ITPA edition of Fall, 1968. It added one additional and two supplemental skills at the automatic level. The new test, visual closure, is described

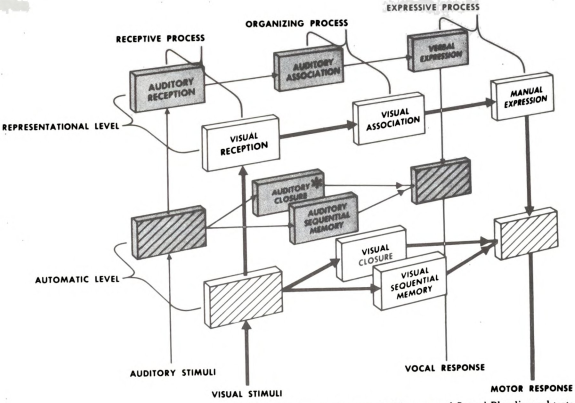


Figure 2. Three-Dimensional Model of the ITPA[a]

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[a]After Kirk, McCarthy and Kirk; 1968. Page 8.

below.

Each of the ITPA sub-tests can be summarized as follows:

Test 1. Auditory Reception (Auditory Decoding), or the comprehension of the spoken word, is tested by the use of a controlled vocabulary test. The S answers yes or no to such questions as Do you eat.... Do you rain.... Do bananas telephone.... Do chateaux chastise?

Test 2. Visual Reception (Visual Decoding), or comprehension of pictures and written words, is assessed by the S being shown a stimulus picture (e.g. a shoe) and then selecting from a set of pictures the one most meaningfully related.

Test 3. Visual-Sequential Memory (Visual-Motor Sequencing), or the ability to reproduce a symbol or object sequence previously seen, is assessed by having the S duplicate the order of a sequence of objects or geometric figures presented to him. Cardboard blocks with the objects and figures are arranged in a particular order, mixed, then the S restores the sequence.

Test 4. Auditory Association (Auditory-Vocal Association), or the ability to relate spoken words, is tested by an analogies test (e.g., John is a boy: Mary is a _____.) The S must supply the appropriate word.

Test 5. Auditory-Sequential Memory (Auditory-Vocal Sequencing), or ability to repeat a sequence of symbols previously heard, is tested through the use of digit repetition. The S repeats a series of digit sequences from two

to seven digits in length.

Test 6. Visual Association (Visual-Motor Association), or the ability to relate meaningful visual symbols, requires the S to choose by pointing to that object or picture which meaningfully relates to a stimulus object or picture (e.g., a shoe - ball, sock: a spoon - car, cup).

Test 7. Visual Closure, is the ability to identify a common object (e.g. dog, bottle, fish, shoe, hammer and saw) from an incomplete visual presentation. Five paper strips are presented to the S independently, one strip for each of the objects in the sub-test. On each strip is a scene with many pictures incompletely presented and the S points out the objects as quickly as possible. An example would be the tail or hindquarters of a dog displayed against the background of a fence. The S should be able to integrate these into completed dogs in his mind.

Test 8. Verbal Expression (Vocal Encoding), or the ability to express ideas in oral language, is assessed by the S describing stimulus objects, such as a ball or block, in terms of its name, qualities, color, use, value, etc.

Test 9. Grammatic Closure (Auditory-Vocal Automatic), or the capability to predict future linguistic events from past experience, is assessed by the S providing a completion to a test statement (e.g., This is a bed:

Here are two ______.)

Test 10. <u>Manual Expression (Motor Encoding)</u>, or the ability to use gestures expressively, is assessed by showing the S a stimulus object and having him supply a motion for manipulating the object (e.g., drinking from a cup or hammering with a hammer).

<u>The Developmental Test of Visual Perception (DTVP)</u>

The Marianne Frostig Developmental Test of Visual Perception (DTVP) developed by Frostig, et al. (1964) assesses defects in five types of visual perception. These are: (a) eye-hand coordination; (b) figure-ground perception; (c) form constancy; (d) position in space; and (e) spatial relationships. These distinct types were postulated from the clinical experience of Dr. Frostig and her associates. Their postulations were supported by research showing the relatively independent development of the areas (Frostig, et al.; 1964). This test was not intended to assess all visual perceptual abilities, but rather only those felt to be of relevance to school performance. The items in the test yield measures (the perceptual quotient and perceptual age) which are indicative of the visual perceptual age of a young child who has taken the test. Further, the sub-tests provide profiles indicating weaknesses which occur in visual perception, and these can be used to establish a specific remedial program designed to correct the deficiency areas.

Each of the sub-tests can be described as follows:

Test 1. Eye-Motor Coordination requires the S to draw straight and curved lines between increasingly narrow boundaries, or to draw a straight line from an object or point to a similar object or point.

Test 2. Figure-Ground has the S discriminate between intersecting and overlapping shapes, and find hidden geometric figures.

Test 3. Constancy of Shape has the S discriminate geometric figures of different shadings, sizes and positions among other shapes on a page.

Test 4. Position in Space assesses directionality by having the S mark the object or figure which is either oriented in a different direction from the others in its group, or matches a stimulus object exactly relative to its position in space.

Test 5. Spatial Relationships has the S copy patterns by linking a series of dots with pencil lines. The S is shown a figure made by connecting dots with lines and is required to reproduce the figure as accurately as possible.

The Purdue Perceptual Motor Survey (PPMS)

The Purdue Perceptual-Motor Survey (PPMS) developed by Roach and Kephart (1966) qualitatively assesses the perceptual-motor abilities of children in the early grades. The authors state its purpose as follows:

> The Perceptual-Motor Survey was designed primarily to detect errors in perceptual-motor development. To date it is a qualitative scale which designates

> areas for remediation. The survey was not designed for diagnosis, per se, but to allow the clinician to observe perceptual-motor behavior in a series of behavioral performances. (Roach and Kephart, 1966; page 11.)

The survey contains 22 items that are divided into 11 sub-tests purported to measure some aspect of the individual's perceptual-motor development. The authors noted that the sub-tests can be divided into three major aspects: (a) laterality; (b) directionality; and (c) perceptual-motor matching. Further, they indicated that the sub-tests will be included in any combination of those three aspects (Roach and Kephart, 1966).

In scoring the PPMS, the authors complicated this procedure by grouping the items and sub-tests into five major areas of performance which were listed as: (a) Balance and Posture; (b) Body Image and Differentiation; (c) Perceptual-Motor Match; (d) Ocular Control; and (e) Form Perception.

Each of the 11 sub-tests may be described as follows:

Test 1. The Walking Board is an elevated two by four board 12 feet in length on which the S is requested to walk forward, backward and sideways.

Test 2. Jumping is a series of jumping, hopping, and skipping tasks which are performed by the S using both feet, one or the other of his feet, or rhythmically using his feet.

Test 3. The Identification of Body Parts is a series of commands given the S to touch body parts (e.g., shoulders, hips, elbows, mouth, etc.).

Test 4. The Imitation of Movements is a series of unilateral

bilateral, and contralateral movements the S imitates while facing the examiner. These movements, using the arms extended to the sides, resemble semaphore signalling.

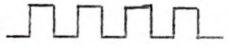
Test 5. The Obstacle Course is three tasks in which the subject steps over a stick placed at knee height between two chairs, ducks under the stick placed at shoulder height, and passes between the end of the stick and a wall without touching either the wall or stick end.

Test 6. The Kraus-Weber consists of two tasks from a familiar physical strength and muscular fitness test. A pillow is placed under the hips of the S in both tasks. In one, he must raise his body off the floor from the waist up for a specific time. In the other, he must raise his legs off the floor for the same time period (e.g., ten seconds).

Test 7. The Angels-In-The-Snow is another series of tasks which the S performs while lying on his back on a floor. The examiner points to a specific arm or leg, or combination of the two limbs, and instructs the S to move the extremities to various positions while maintaining contact with the floor with the limbs.

Test 8. The Chalkboard consists of four tasks which the S must perform by using chalk and a board. The first two concern the drawing of circles, first with one hand, and then simultaneously with both hands. The last two tasks require the drawing of vertical and

horizontal lines. First, the S connects two X's with a straight horizontal line. Then, he draws vertical lines, simultaneously and bilaterally, from X's placed on the board, considerably above his head, to the board bottom.

Test 9. Rhythmic Writing is a series of writing tasks in which the S reproduces a pattern that the examiner places on a blackboard. There are eight patterns or motifs for reproduction (e.g., , *eeeeeee*, *pbpbpb*, etc.).

Test 10. Ocular Pursuits is a series of tasks using a pen-light and occluder (eye cover) in which the S's ability to follow the light beam is assessed for binocular and right-left monocular vision.

Test 11. The Visual Achievement Forms are seven tasks which the S completes by reproducing geometric forms (e.g., circle, cross, square, triangle, horizontal diamond, vertical diamond, and divided rectangle). This test is also called Developmental Drawings.

## The Wepman Auditory Discrimination Test (WADT)

The Wepman Auditory Discrimination Test (WADT), developed by Wepman (1958), is a method for determining a subject's ability to recognize fine differences between English speech phonemes. The author notes that it measures only the ability to hear accurately. Two comparable forms have been developed. Each form consists of 30 word-pairs, each word-pair differing

by a single phoneme, and ten word-pairs in which there is no difference among any of the word pairs. The phonemes contrasted belong to the same articulatory category (e.g., stops, etc.) and the word-pairs are equated for length. The latter cautions eliminate discriminations on the basis of contrasting articulatory category, or contrasting length, and force a choice on the basis of the differing auditory characteristic (Wepman, 1958). The word-pairs are matched for familiarity using the Lorge-Thorndike Teacher's Word Book of 30,000 Words. The word-pairs which are not different provide a check against guessing. The examiner reads the word-pairs aloud to the S, whose back is turned to him. The S replies, "same" or "different," to each word-pair, depending upon his discrimination ability. Examples of the word-pairs used in this brief test are web-wed, shake-shape, thread-shred, thimble-symbol, etc.

## Review of Research

### General Theoretical Models - The Structure of Intellect

Underlying this review is the basic assumption that the reader is familiar with one purpose of factor studies, which is to explain data simply and meaningfully (Harman, 1967). An effort has been made by the investigators reviewed here, to identify specific ability factors. This procedure has ample precedent in the literature, best exemplified by the work of J. P. Guilford (1958; 1966; and 1967). No exhaustive review of Guilford's research will be presented, but it is necessary to present summaries of two of his theoretical models.

The first is a multifactor model of intelligence called the Structure of Intellect-SI (Guilford, 1959). The SI is relevant here because several investigators in this review have employed this model to describe their factors, and because it provides a simple classification scheme for abilities. Guilford has proposed a three dimensional model to identify the factors of intelligence or intellect (See Figure 3). These dimensions are operations, content, and products. Each intellectual component or factor can be identified by a three letter code (trigram) specifying: (a) one of the five operations or processes of intellect (e.g., cognition, memory, divergent thinking, convergent thinking, and evaluation); (b) one of the four content areas (e.g., figural, symbolic, semantic, and behavioral); and (c) one of six products of intellect (e.g., units, classes, relations, systems, transformations, and implications). Using this model as a theoretical basis for describing intelligence factors, Guilford identified and classified tasks representing the specific factors he needed to verify. He has presented a summary of SI factors and associated tasks for the interested reader (Guilford, 1966 and 1967).

General Theoretical Models-Psychomotor Abilities

Guilford (1958) also presented a theory of psychomotor abilities similar to his SI model. He reviewed the literature, and as a result classified the empirical data into theoretical psychomotor ability factors, based upon a two dimensional matrix. The first dimension, part of the body involved, includes: the

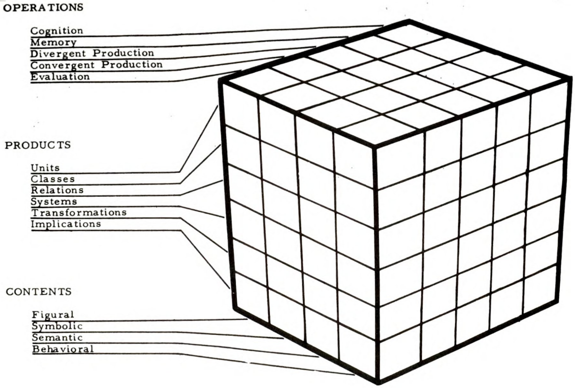



Figure 3. The Structure of Intellect[a]

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[a]After Guilford, 1966. p. 21.

gross body, trunk, limbs, hand, and finger parts. The second dimension, type of ability, includes: strength, impulsion ("rate at which movements are initiated from stationary positions"), speed, static precision ("the accuracy with which bodily positions can be held"), dynamic precision ("precision of directed movements"), coordination, and flexibility. His psychomotor ability matrix is reproduced in Table 1. and will be used in the present study as a simple classification scheme for factors.

ITPA Factor Studies

A number of factor analytic studies have been conducted of the ITPA. These studies were summarized by Meyers (1968), who presented a synthesis of 16 factor studies of the ITPA. The latter studies are grouped according to their utility in the identification of ability factors on which specific ITPA sub-tests appear saturated. Using the SI code as well as general descriptive names, Meyers concluded that the ITPA best measures three factors. The first, a verbal comprehension factor, whose SI label is Cognitive-Convergent Semantics (C-NM), saturates with the ITPA sub-tests of Grammatic Closure and Auditory Association. The remaining two factors are visual-motor dimensions. The first of these, "vocal motor expression" or, by SI label, Convergent Production of Semantic Relations (NMR), loads with the Visual Reception, Manual Expression, and Verbal Expression sub-tests. The final visual motor factor, whose SI label is Cognition of Semantic Relations (CMR), is saturated

Table 1. Matrix of Psychomotor Abilities[a]

| Part of Body Involved | Type of Ability: Strength | Impulsion | Speed | Static Precision | Dynamic Precision | Coordination | Flexibility |
|---|---|---|---|---|---|---|---|
| Gross | General strength | General reaction-time | | Static balance | Dynamic balance | Gross bodily coordination | |
| Trunk | Trunk-strength | | | | | | Trunk-flexibility |
| Limbs | Limb-strength | Limb-thrust | Arm-speed | Arm steadiness | Arm-aiming | | Leg flexibility |
| Hand | | Tapping | Hand-speed | | Hand-aiming | Hand dexterity | |
| Finger | | | Finger-speed | | | Finger dexterity | |

[a]After Guilford, 1958. Page 165.

by the Visual Sequential Memory sub-test. Meyers posits four other factors in his synthesis which show less reliability than the three above. He suggests these to be tentative factors, pending further confirmation. His criteria for establishing the validity of the first three factors were: (a) substantiation through his own synthesis of ITPA factor research, and (b) related factor research in the literature which confirmed the existence of those factors. Critical reservations should be held regarding the comparability of factors from different analyses. Nunnally (1967) has indicated a procedure for such comparison. However, this writer feels the use of SI labels and Meyers' technique of grouping his studies somewhat mitigates this reservation. His work represents a major contribution to understanding the factorial composition of the ITPA.

Hueftle (1967), in an investigation not reported by Meyers, studied the factor structure of three instruments: the ITPA, Frostig's DTVP, and the WISC. Meyers used 50 subjects, who were drawn in a random stratified sample, based on paternal educational levels, disregarding race, creed, sex, and intelligence. He did separate analyses for each test, as well as one for the 26 variables included in his research. He presented nine factors, four of which are relevant to the present discussion. His second factor, visual-hand, was loaded by ITPA variables. Hueftle's third factor, an auditory visual memory cluster, was also loaded heavily with ITPA variables. The fifth factor, which was loaded most heavily with the DTVP, represented a collapsing of two factors which appeared in the

separate DTVP analysis. Factor nine was comparable to a quasi-unique (author's term) factor generated by the separate ITPA analysis and was similar to J. S. Cohen's (1949) Freedom from Distractibility factor. It appears that the ITPA accounted for three of the factors reported by Hueftle with the DTVP forming the other one.

A critique of the Hueftle study could not overlook the following points. Factors generated from heterogeneous samples are questionable and the composition of Hueftle's population was not homogeneous (Guilford, 1952; Nunnally, 1967). The DTVP and the ITPA were standardized on non-Black populations which casts doubt on the validity of Hueftle's scores (McCarthy and Kirk, 1961; Frostig, et al., 1963). Finally, the ratio of subjects to variables should be at least ten to one in order to calculate stable loadings and factors (Nunnally, 1967).

The authors of the ITPA originally interpreted the experimental edition as having six factors accounting for 86% of the variance (McCarthy and Kirk, 1963). This interpretation, using unrotated data, was somewhat tenuous because the first factor was loaded by all nine sub-tests, in excess of .8 for each subtest. These extremely high loadings on the first factor, a general linguistic ability dimension, cast doubt on the meaning of successive factor values. Furthermore, this first factor accounted for 72% of the variance, while the remaining five factors could each account for only 3% or less. Interpretation of factors accounting for such small amounts of variance may be questioned because of the magnitude of the first factor. Their factor interpretation casts serious doubt on the McCarthy and Kirk conclusions and leads to characterization of the ITPA as an unifactorial test.

The acceptance of the factor interpretation by McCarthy and Kirk ignores the fact that the ITPA is a nine dimension test (presently ten) and only six factors appeared in their analysis. This observation suggests the need for further research on the factor structure of the ITPA.

Kirk and Paraskevopoulos (1969) will release in late May, a book discussing the standardization of the revised edition of the ITPA. It is assumed that the factor structure of the ITPA will be part of their analysis.

Center (1963) correlated the ITPA with an achievement test and found that the seven sub-tests loaded on four factors. Two of the sub-tests divided their variance between two factors. On the basis of these results it appears that the sub-tests do not correspond to the theoretical model. Center called for further research using factor methods to clarify the problems of implementing Osgood's model at the automatic and representational level.

Using the SI model, Loeffler (1963) hypothesized seven ability dimensions. He factored 32 tests labelled with appropriate SI codes, including the ITPA. Six dimensions factored out with the sub-tests of the ITPA loading on five of the abilities. The second factor, verbal comprehension, loaded with the ITPA Grammatic Closure sub-test. All the test variables in the

verbal comprehension factor were classified either as Convergent Production of Semantic Units (NMU) or Cognition of Semantic Units (CMU). The third factor, fluency, whose SI label Divergent Production of Semantic Units (DMU), was represented by the ITPA Verbal Expression sub-test. Figural reasoning, factor four, was loaded by Visual Association and Visual Reception. The latter was classified as Cognition of Figural Classes (CFC) and the former as Cognition of Figural Relations (CFR). Immediate memory for symbolic units (Auditory), factor six, loaded with the sub-test, Auditory Sequential Memory. Its SI label was Memory of Symbolic Units (MSU). The final test, Visual Sequential Memory, loaded on factor seven, immediate memory for figural units (Visual). Memory for Figural Units (MFU) was its SI label.

DTVP Factor Studies

Two studies using the DTVP were published by Corah and Powell (1963) and Sprague (1963). The latter investigator correlated the DTVP with achievement measures. Sprague's results showed four sub-tests loading on two factors. The Eye-Motor Coordination and Figure-Ground sub-tests loaded .4 on a factor accounting for 5½% of the common factor variance. The Position in Space and Spatial Relations sub-tests contributed substantially larger loadings on their factor. These two variables were interpreted as a space relations factor accounting for 10.4% of the variance.

Corah and Powell (1963) compared the DTVP with the following tests: the Full-Range Picture Vocabulary Test (FRPV), an intelligence measure; the Ghent Overlapping Geometric Figures Test (OGF), a measure of form discrimination; and a form constancy task (FC). They concluded that two factors could explain the greater share of the variance accounted for in the analysis. These two factors were labelled general intelligence and developmental change in perception. Corah and Powell suggested that the perceptual quotient (PQ - Total score on test) should be given more attention as a good measure of the latter factor. The meaning of the results, using sub-test scores, was questioned because of reliability problems associated in the use of difference profiles. As age increased, individual sub-test scores became more reliable, and it was concluded that scatter analysis of the sub-tests for this reason was questionable.

One implication of Corah and Powell's study is that the DTVP is a unifactorial test. This conclusion is supported by two sources. Hueftle's study, cited above, identified a factor on which the DTVP loaded almost exclusively, and Corah and Powell observed that the PQ (total score on test) should be given more attention as a measure of their second factor.

A final note regarding the DTVP's status as a unifactorial or multifactorial test was offered by Frostig, et al (1964). They wrote in reference to the PQ:

> The use of any unitary measure of perceptual function may suggest that it expresses some common trend or factor. But the five sub-test scores are based on the assumption

> that essentially five different and relatively independent abilities are tested and may subsequently be differentially trained. (page 481).

The two remaining instruments used in the present study appear not to have been the subject of published factor analytical studies.

PPMS Factor Study

This writer did factor analyze the intercorrelation matrix (Table 2) in the Manual for the Purdue Perceptual Motor Survey (PPMS) by Roach and Kephart (1966)[1]. Six clusters appeared with factor loadings between .54 and .83. Three tasks did not load on any cluster. These tasks were the obstacle course, the Kraus Weber, and the Angels-in-the-Snow. The six clusters and their tasks were: (a) the Walking board tasks; (b) the Chalkboard tasks; (c) the Ocular Pursuits tasks; (d) the Developmental Drawing tasks; (e) the Rhythmic Writing tasks; and (f) Jumping, Identification of Body Parts, and Imitation of Movements.

Factor three, ocular pursuits, accounted for 26% of the variance. This was the largest share with the other factors each sharing between 5 and 8%. The total amount of the variance explained by the factor analysis was 61%.

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[1]The authors maintain the PPMS items are not factorially pure (1966; page 70), although there are striking similarities between the factor structure above and the PPMS "major areas of performance" (Re: page 9-10 of this discussion and note Table 2 on the following page).

Table 2. Correspondence of PPMS Tasks in Each of the Authors' "Major Area of Performance" to the Writer's Factor Analysis of the PPMS Intercorrelation Matrix.

| Roach-Kephart's Major Areas of Performance | PPMS Tasks | Factor |
|---|---|---|
| 1. Balance and posture | Walking board | One |
| | Jumping | Six |
| 2. Body image and differentiation | Identification of body parts | Six |
| | Imitation of movements | Six |
| | Obstacle course | Omitted tasks |
| | Kraus-Weber | Omitted tasks |
| | Angels-in-the-Snow | Omitted tasks |
| 3. Perceptual-motor match | Chalkboard | Two |
| | Rhythmic writing | Five |
| 4. Ocular pursuits | Ocular pursuits | Three |
| 5. Developmental drawing (Visual Achievement Forms) | Developmental drawing | Four |

WADT

The Wepman Auditory Discrimination Test (WADT) appears to be a unifactorial test because all 40 items are of a similar nature. Presumably, Memory of Symbolic Units (MSU) would be an appropriate SI label and category for this test.

## Summary of Research Review

In summary, of the four instruments, one - the ITPA - has been subjected to the most complete factor study. The results suggest that it is at least a three factor test. Considerable doubt exists about the factorial status of the DTVP, PPMS, and the WADT.

## Hypotheses

The preceding two sections have brought together from three sources most of what is known about the factors underlying the battery of tests used in the present investigation: (a) A clear description of the nature of the tasks encompassed by each subtest was given; (b) The research inconsistencies apparent within each test's factorial construction were noted; and (c) two systems were presented, both elaborated upon by J. P. Guilford, for the classification of tasks into a hypothetical factor structure. These three sources were used to develop in tabular form this writer's hypothesized factor structure for the battery of tests (Table 3).

The 16 hypothesized factors parsimoniously explain the nature of the tasks included in this battery. Hypothesized factors 1 - 3

Table 3. Hypothesized Factor Structure of Four Tests of Learning Disabilities.

| | Hypothesized Factor Name and Code | Common Name | Test(s) | Research Source | Factor Status[a] |
|---|---|---|---|---|---|
| 1. | Cognition of Semantic Relations (CMR) | Semantic Relations | ITPA Aud. Rec.<br>ITPA Vis. Ass'n. | Meyers (1968) | Confirmed |
| 2. | Convergent Production of Semantic Relations (NMR) | Semantic Correlates | ITPA Vis. Rec.<br>ITPA Verb. Exp.<br>ITPA Man. Exp. | Meyers (1968) | Confirmed |
| [b]3. | Cognition-Convergent Semantics (C-NM) | Verbal Comp. | ITPA Aud. Ass'n<br>ITPA Gramm. Cloze. | Meyers (1968) | Confirmed |
| 4. | Memory for Symbolic Systems (MSS) | | ITPA Aud. Seq. Mem. | Meyers (1968) | Tentative |
| 5. | Memory for Figural Systems-visual (MFS-v) | | ITPA Vis. Seq. Mem. | Meyers (1968) | Tentative |
| 6. | Cognition of Figural Systems (CFS) | Spatial Orient. | DTVP Pos. in Sp<br>DTVP Spat. Rel | Sprague (1968) | Tentative |
| 7. | Cognition of Figural Units-visual (CFU-v) | | DTVP Eye Mot. Coord.<br>DTVP Fig. Grnd.<br>DTVP Cons. Shape | Sprague (1968) | Tentative |
| 8. | Memory for Symbolic Units (MSU) | | WADT | | |
| [c]9. | Trunk-Strength | | PPMS Krause-Weber | Guilford (1958) | |
| 10. | Limb-Thrust | | PPMS Jumping | | |
| 11. | Static-Balance | | PPMS Walk Bd | | |
| 12. | Arm Steadiness | | PPMS Chalkbd | | |
| 13. | Arm Aiming | | PPMS Indent Bod Pts<br>PPMS Imit. Move. | | |
| 14. | Gross Bodily Coordination | | PPMS Obstacle Cse<br>PPMS Angels-in-Sno | | |
| [d]15. | Ocular Pursuit | | PPMS Ocular Pursuits | | |
| [e]16. | Memory for Figural Units (MFU) | Memory-Motor | PPMS Rhythm Writing<br>PPMS Develop Drwngs<br>(Visual Achievement Forms) | | |

a According to research reported.

b Author's use of Guilford's SI model deviates from accepted practice by using two operations and not designating a product.

c Factors 9-14 are hypothesized using the task descriptions contained in Guilford (1958). All are tentative status.

d Factor 15 is hypothesized because its existence appears consistent with the Psychomotor Ability Matrix.

e Factor 16 used the SI model because the required tasks seemed more adequately described by that model.

were strongly substantiated by Meyers' research. Hypothesized factors 4 and 5 are tentative but Meyers suggested that it is reasonable to expect their presence. It appears that five factors explain the nature of the present ITPA if these hypotheses are confirmed. Hypotheses 6 and 7 predict the DTVP structure as a two factor test. This is consistent with Sprague's results but questions those of Hueftle and Corah and Powell. The decision to predict two factors results from differences seen in the nature of the tasks as described by Frostig and their similarity to the two SI factors by which they are classified. Hypothesized factor 8 explains the WADT because the task description from the SI model most closely resembles the WADT task.

Hypothesized factors 9 - 14 were classified as a result of their similarities to Guilford's description of tasks representing the psychomotor abilities he proposed as separate psychomotor functions. Factor 15, ocular pursuits, appears to be an eye-motor coordination cluster not identified by Guilford's model but consistent with its structure. It loaded separately in the PPMS analysis reported, and it is predicted to load separately in the hypothesized factor matrix. Finally, hypothesized factor 16 combines two tasks which loaded separately in the PPMS analysis but whose description matches the SI task by which they are coded.

In conclusion, 16 factors were hypothesized, at a maximum, to parisimoniously explain the data derived from four tests of

learning disabilities--the ITPA, the DTVP, the WADT, and the PPMS. These 16 hypotheses are:

Hypothesis 1. The ITPA sub-tests, Auditory Reception and Visual Association, associates with a semantic relations dimension whose label is Cognition of Semantic Relations.

Hypothesis 2. The ITPA sub-tests, Visual Reception, Verbal Expression, and Manual Expression, associates with a semantic correlates dimension whose label is Convergent Production of Semantic Relations.

Hypothesis 3. The ITPA sub-tests, Auditory Association and Grammatic Closure, associates with a verbal comprehension dimension whose label is Cognition Convergent Semantics.

Hypothesis 4. The ITPA sub-test, Auditory Sequential Memory, associates with a symbolic memory dimension whose label is Memory for Symbolic Systems.

Hypothesis 5. The ITPA sub-test, Visual Sequential Memory, associates with a figural memory dimension whose label is Memory for Figural Systems--visual.

Hypothesis 6. The DTVP sub-tests, Position in Space and Spatial Relations, associates with a spatial orientation dimension whose label is Cognition of Figural Systems.

Hypothesis 7. The DTVP sub-tests, Eye-Motor Coordination, Figure-Ground, and Form Constancy, associates with a figural recognition dimension whose label is Cognition of Figural Units-visual.

Hypothesis 8. The WADT associates with a symbolic memory dimension whose label is Memory for Symbolic Units.

Hypothesis 9. The PPMS sub-test, Kraus-Weber, associates with a psychomotor ability dimension whose label is Trunk-Strength.

Hypothesis 10. The PPMS sub-test, Jumping, associates with a psychomotor ability dimension whose label is Limb-Thrust.

Hypothesis 11. The PPMS sub-test, Walking Board, associates with a psychomotor ability dimension whose label is Static Balance.

Hypothesis 12. The PPMS sub-test, Chalkboard, associates with a psychomotor ability dimension whose label is Arm Steadiness.

Hypothesis 13. The PPMS sub-tests, Identification of Body Parts and Imitation of Movements, associates with a psychomotor ability dimension whose label is Arm Aiming.

Hypothesis 14. The PPMS sub-tests, Obstacle Course and Angels-in-the-Snow, associates with a psychomotor ability dimension whose label is Gross Bodily Coordination.

Hypothesis 15. The PPMS sub-test, Ocular Pursuits, associates with an eye muscle coordination dimension whose label is Ocular Pursuits.

Hypothesis 16. The PPMS sub-tests, Rhythmic Writing and Visual Achievement Forms, associates with a figural memory dimension whose label is Memory for Figural Units.

# CHAPTER II

## METHODOLOGY AND PROCEDURES

The procedures used in the study are presented in this chapter. Sample selection, examiner training, instrumentation, and procedures, etc. are discussed in detail.

### Subjects

The Ss used in this study were disadvantaged kindergarten children from the Grand Rapids public and parochial school systems. They are participating in an OEO Study of Disadvantaged Children (Ericson, McMillan and Bonnell, 1968 et. seq.). The children were classed as disadvantaged under two OEO criteria. These criteria relate the number of persons in a family to their combined income to determine if a person may be described as disadvantaged. As examples of this: The poverty level for a family of four is thirty-two hundred dollars, for a family of five persons the corresponding income level is thirty-seven hundred dollars, and a family of more than five may earn up to five hundred dollars more to support each additional member of the family. Of the 327 Ss available in the original subject pool, 22 Ss did not complete the basic three-test battery composed of the ITPA, the DTVP, and the WADT. The Ns used in each statistical analysis are reported in Table 4.

Table 4. Composition of Sample-groups for Analyses.[a]

| Sex | 3-Test Sample | 4-Test Sample | I.Q. Sample |
|---|---|---|---|
| Male | 148 | 40 | 105 |
| Female | 157 | 53 | 103 |
| Total N | 305 | 93 | 208 |

[a]All Ss drawn from original S pool of 305.

Because of time limitations, examiner shortage, and scheduling difficulties it was decided to administer the PPMS to a sample of 100 Ss. An additional conflict with another testing schedule reduced the N for this factor study to 93 Ss.

A third group of 208 Ss, whose Stanford Binet I.Q. was known, constituted the final sample used for analysis in this study.

The age range for the Ss in the three samples above was 62-84 months, with a mean of 68 months and S.D. of four months.

## Instrumentation and Procedures

The battery of tests used in this study is described in Chapter I. During the administration and scoring of these tests, the procedures outlined in the respective test manuals were followed as closely as possible. A sample pre-test indicated the necessity to modify two tests during the data collection. Descriptions of these modifications follow:

1. The WADT was recorded on tape in the MSU Speech Laboratory. Copies of this tape were made to assure a standard administration of the test. All Ss were given the test on identical tape recorders. This procedure is contrasted with the usual administration in which the examiner reads the word-pairs aloud at an intensity and frequency which varies from examiner to examiner and from word-pair to word-pair.
2. The PPMS Rhythmic Writing sub-test is not

intended for children under eight. After brief experimentation by this investigator, it was decided that the Ss were capable of responding to the first three motifs. These results are included in the data.

Otherwise, the test administration and scoring procedures recommended by each test author were strictly followed during the study.

Examiner Training

Because of the large number of Ss and the length of the total test battery, 13 examiners were recruited to aid in the data collection. All the examiners were senior college students majoring in Education or Psychology. Their training began with an introduction and discussion of the test theory and test materials. Each examiner was given a set of the test materials for familiarization purposes. An added recommendation was given that the examiners practice on neighborhood children. The examiners then observed an administration of the test by a qualified psychometrician. These observations were followed by supervised administrations in which the examiners did the testing. The writer and the psychometrist were available for consultation on any problems of administration and scoring. In addition, the writer periodically observed all examiners during the data collection. In this manner, serious efforts were made to standardize procedures of data collection.

Data Collection

The Ss were located in 32 Public and Parochial Schools in Grand Rapids. Each S was administered each test individually. Earlier plans to test in groups did not prove practical because of limited testing space in the schools. Also, the Ss became distracted by the presence of peers.

The S's responses were recorded on the test forms and keypunched by sub-test scores using a numeric code on IBM data cards. Each S was differentiated from the other Ss by a three-digit identification code.

Statistical Analyses

All computer analyses used in this study were completed on the MSU CDC 3600 computer.

The major objective of this study was to determine the underlying dimensions of the four tests used for assessing learning disabilities. To achieve this objective, the data were submitted to principal Axis Factor Analysis with Varimax Rotation. The particular program used was developed by the MSU Computer Institute for Social Science Research (1967). To make the resulting analyses more readily interpreted, they were rotated orthogonally using the varimax method. The cut-off index for determining the number of factors to be rotated was an eigenvalue of 1.000. This index is accepted routinely in factor research as an appropriate level for determining the number of factors to be rotated.

Separate factor analyses were performed to determine the empirical factor structure for the following:

1. The ITPA, the DTVP, and the WADT for 305 Ss;
2. The ITPA, the DTVP, the WADT, and the PPMS for 93 Ss;
3. The ITPA for 305 Ss;
4. The DTVP for 305 Ss; and
5. The PPMS for 93 Ss.

Lange (1969) studied the question of stable factor loadings and concluded that a minimum N of 400 is needed. However, in all present analyses except #2 and #5, a minimum subject-variable ratio of 10:1 was imposed on the data (Nunnally, 1967). The suggested ratio proposed assures stable factor loadings. Other factor research on meaningful factor loading levels suggests a minimum N of 200 Ss (Guilford, 1954). These criteria were also met by the present study.

Exceptions to the criteria described above were analyses #2 and #5. These exceptions were necessary because of a conflict in scheduling. To complete the additional Ss would have required delay in the Spring test program of the school systems involved. Despite this difficulty, it was felt that useful information would be wasted if the PPMS analyses across the tests and individually were not completed. Subsequent interpretation of these analyses presented in the results, will take into account the failure to meet the subject-variable ratio criterion.

In addition to the factor analyses, the data were subjected to analytical routines which were felt to strengthen the assump-

tion of homogeneity for the samples, and to determine the usefulness of the sub-tests as predictor variables.

An analysis of variance routine for unequal Ns was employed to determine the effects of age and sex on the samples. The 3-Test sample was divided into three age groups of one-half year intervals. This alternative was taken after it was found that the Ns could not be divided into three month intervals consistent with the norms reported in the ITPA and DTVP test manuals. The three month Ns would have been too small for meaningful analysis. The presence of non-significant cell differences lends support to the assumption of sample homogeneity. Further, non-significant differences due to age would bring into question the value of the tests included in the battery as developmental indices.

Finally, multiple regression analyses routines were used to determine the ability of the following independent variables to predict I.Q.: sex, age, the sub-test scores of the ITPA, the DTVP, and the WADT.

Two step-wise regression programs were employed to identify the predictor variables (MSU Agricultural Research Station, 1967, 1968). These were the Step-wise Deletion of Variables From a Least Squares Equation (LSDel) Routine and the Step-wise Addition of Variables To Form a Least Squares Equation (LSAdd) Routine. Each procedure is essentially the reverse of the other.

The general procedure used in the LSDel Routine begins with a multiple regression equation using as predictors all the independent variables, then deleting the variables one at a time.

The order of deletion is determined by the amount of variance accounted for by each independent variable. The variables eliminated are those which account for less than a predetermined amount of variance. Each of the retained variables accounts for variance in excess of that amount. The level of significance chosen for both routines was .05.

The LSAdd Routine begins with the independent variable contributing the most variance to the multiple correlation. Then variables are added in order of the magnitude of the variance accounted for until all variables are added.

These two routines identify the major predictor variables in terms of variance contribution to the criterion prediction. The method employed above is fully described by TenBrink (1968).

## CHAPTER III

## RESULTS

The data analyses, reported here, are the results of six factor analyses, a two-way analysis of variance, and two stepwise multiple regression analyses. Factor analyses are reported for a Three-Test Battery, comprised of the ITPA, the DTVP, and the WADT, as well as for a Four-Test Battery, which included the latter three tests and the PPMS. In addition, separate factor analyses for each test are reported.

### Factor Analyses: Introduction

The basic technique employed in this study was that of factor analysis. The major hypotheses relate to the number of underlying dimensions or factors which appear to explain parsimoniously the set of the sub-test variables.

Means, standard deviations, and intercorelation matrices were computed and are presented in Appendix I. The inter-correlation matrices were submitted to Principal Axis Factor Analysis with Varimax Rotation. The number of factors to be rotated was determined by an eigenvalue of 1.000.

The interpretation of the separate factors in the factor solutions presented below depends on two considerations: (a) The strength of the association of a particular variable

with its factor as measured by the factor loading; and (b) The consistency with which particular variables associated on the same factor.

Factor Analyses: Three-Test Battery

Table 5 contains a listing of the sub-test variables and the abbreviations used in the subsequent data analysis tables.

The analysis for the Three-Test Battery was done by submitting the intercorrelation matrix for the three tests to Principal Axis Factor Analysis with Varimax Rotation. The results are presented in Tables 6-11.

The solution which best explained the dimensionality of the 17 sub-test variables included in this analysis contained five factors. This solution accounted for 59% of the factor variance across the Three-Test Battery. One factor, Factor III, accounted for 7% of this factor variance. The remaining four factors each accounted for at least 10% of the factor variance (Table 6).

Every factor in this solution was loaded with variables whose minimum factor loadings were .50. The decision to use factor loadings of .50 was an arbitrary one made by the investigator. Other studies have employed smaller variable values, but it was felt that a variable accounting for at least 25% of the factor variance, a factor loading of .50, would contribute to the interpretation of the factor. In addition, each factor had one variable associated with it which loaded at least .70. The sample size used to obtain this solution exceeded the

TABLE 5

Abbreviations Used in the Data Report

## Test Variables

**The Illinois Test of Psycholinguistic Abilities (ITPA)**

| | | |
|---|---|---|
| 1 | AR | - Auditory Reception |
| 2 | VR | - Visual Reception |
| 3 | VSM | - Visual Sequential Memory |
| 4 | AA | - Auditory Association |
| 5 | ASM | - Auditory Sequential Memory |
| 6 | VA | - Visual Association |
| 7 | VC | - Visual Closure |
| 8 | VE | - Verbal Expression |
| 9 | GC | - Grammatical Closure |
| 10 | ME | - Manual Expression |

**The Frostig Developmental Test of Visual Perception (DTVP)**

| | | |
|---|---|---|
| 11 | EMC | - Eye-Motor Coordination |
| 12 | FG | - Figure-Ground |
| 13 | FC | - Form Constancy |
| 14 | PIS | - Position in Space |
| 15 | SR | - Spatial Relations |

**The Wepman Test of Auditory Discrimination (WADT)**

| | | |
|---|---|---|
| 16 | DIFF | - Different Word-Pairs |
| 17 | SAME | - Same Word-Pairs |

**The Purdue Perceptual Motor Survey (PPMS)**

| | | |
|---|---|---|
| 18 | WB | - Walking Board |
| 19 | JP | - Jumping |
| 20 | IBP | - Identification of Body Parts |
| 21 | IM | - Imitation of Movements |
| 22 | OC | - Obstacle Course |
| 23 | KW | - Kraus-Weber |
| 24 | AIS | - Angels-in-the-Snow |
| 25 | CB | - Chalkboard |
| 26 | RW | - Rhythmic Writing |
| 27 | OP | - Ocular Pursuits |
| 28 | VAF | - Visual Achievement Forms |

subject-variable ratio criterion discussed in Chapter II.

The five sub-test variables of the Frostig loaded on Factor I, Visual Perceptual Relations (Table 7). This set of sub-test variables accounted for 17% of the factor variance in the three test solution. The variables having the highest loadings were the Figure-Ground and Spatial Relations sub-tests which had loadings of .73 and .74 respectively. These variables each accounted for at least 49% of the factor variance associated with the factor.

It will be recalled that a factor loading is the measure of association of a variable with a factor. In variance terms, the factor loading is the square root of the variance. To obtain an estimate of the factor variance accounted for by a variable it is necessary only to square the loading and read the resulting figure as a percentage. A variable with a loading of the magnitude of .70 is generally considered to have a high association with the factor on which it loads.

The remaining sub-tests, Eye-Motor Coordination, Form Constancy, and Position in Space, had substantial factor loadings (nearly .60) with Factor I. The association of these five sub-tests appears quite clear here. However, when the DTVP was analyzed separately, the Form Constancy variable formed a separate factor. This inconsistency was minimized to some extent because the factor did not meet the eigenvalue criterion. Further, the interpretation of a univariable factor is quite difficult. It is recommended that at least two

TABLE 6

Varimax Rotation Factor Loadings of All Variables for Three Tests on a Five Factor Solution.[a]

| | Factors | | | | |
|---|---|---|---|---|---|
| Variables | I | II | III | IV | V |
| 1 AR | | | | | -.58 |
| 2 VR | | | | | -.75 |
| 3 VSM | | | | .50 | |
| 4 AA | | | | | -.49 |
| 5 ASM | | | | .77 | |
| 6 VA | | | | | -.64 |
| 7 VC | | | | | -.62 |
| 8 VE | | .85 | | | |
| [b]9 GC | | | | | |
| 10 ME | | .83 | | | |
| 11 EMC | .58 | | | | |
| 12 FG | .73 | | | | |
| 13 FC | .59 | | | | |
| 14 PIS | .59 | | | | |
| 15 SR | .74 | | | | |
| 16 DIFF | | | .76 | | |
| 17 SAME | | | -.77 | | |
| Eigenvalues | 5.1546 | 1.4358 | 1.3122 | 1.1029 | 1.0210 |
| % Var Accounted for by Factor | 17 | 10 | 07 | 11 | 14 |

Total Var accounted for by Five Factor Solution 59%

[a]N = 305

[b]This variable did not load above .50 on any factor.

TABLE 7

**Factor I.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Three Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 11 EMC | .58 | .26 | V | .47 | |
| 12 FG | .73 | .23 | V | .59 | |
| 13 FC | .59 | .17 | IV | .39 | |
| 14 PIS | .59 | .28 | IV | .49 | |
| 15 SR | .74 | .23 | V | .66 | |
| Eigenvalue 5.1546 | | | | | |
| % Var acct'd for by Factor | 17 | | | | 59% |

[a]Five factor solution

[b]N = 305

variables be associated with a factor before any attempt is made to interpret it. Factor I, as presented in Table 7, is probably the best characterization of the Frostig Test variables.

The ITPA sub-test variables, Verbal and Manual Expression, loaded together on Factor II, Verbal-Manual Expression (Table 8). These two variables had factor loadings of .85 and .83 respectively. Factor loadings of this magnitude usually indicate a very high degree of association. A comparison of the variable's secondary factor loading with the primary loading is an indication of the degree of association. Therefore, since the secondary loadings were .14 and .11 respectively, the comparison showed that the sub-test, Verbal Expression, accounted for 69% of its primary factor variance but less than 2% of its secondary factor variance. Similarly, Manual Expression accounted for 68% of its primary factor variance but less than 2% of its secondary factor variance. These two variables loaded on the same factor in every analysis performed in this study. Because of the high loadings on Factor II and the consistency with which these variables loaded on this factor, it was felt to be the most stable factor identified in this study.

Factor III, Auditory Discrimination, was defined by the two Wepman sub-tests (Table 9). DIFFERENT word-pairs had a factor loading of .76, while SAME word-pairs had a loading of .78. These two sub-tests were not associated in the Four-Test

TABLE 8

Factor II.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Three Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 8 VE | .85 | .14 | IV | .76 | |
| 10 ME | .83 | .11 | I | .72 | |
| Eigenvalue 1.4358 | | | | | |
| % Var acct'd for by Factor 10 | | | | | 59% |

[a]Five factor solution

[b]N = 305

TABLE 9

**Factor III.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Three Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 16 DIFF | .76 | .40 | IV | .79 | |
| 17 SAME | -.78 | .28 | IV | .76 | |
| Eigenvalue 1.3122 | | | | | |
| % Var acct'd for by Factor 7 | | | | | 59% |

[a]Five factor solution

[b]N = 305

analysis to be presented later. However, the data presented in Table 9 were more reliable because they were based on a much larger sample.

Visual Sequential Memory, an ITPA sub-test, loaded on Factor IV (Table 10). Its loading of .50 was the minimum level for accepting a variable for interpretation with a factor. The other sub-test which loaded on this factor was Auditory Sequential Memory and its loading was .77. The variables, Auditory Sequential Memory and Visual Sequential Memory, had their highest loadings on the same factor, in the separate ITPA analysis presented below. These two sub-tests appeared to measure the same abilities in the auditory and visual channels described in the ITPA theoretical model in Chapter I. Together, these variables accounted for 11% of the factor variance across the factor solution. Since these two tests measured a type of serial learning ability, Factor IV was labelled a Serial Learning factor.

Five ITPA sub-test variables comprised Factor V, Auditory-Visual Understanding (Table 11). The Visual Reception sub-test had a factor loading of .75 on this factor. Two other sub-tests, Visual Association and Visual Closure, had substantial factor loadings, .63 and .62 respectively. The remaining two variables, Auditory Reception and Auditory Association, had factor loadings of .58 and .49 on Factor V. The latter factor loading was below the minimum level accepted in this study for interpretation; however, this variable consistently loaded on this factor in all subsequent analyses.

TABLE 10

**Factor IV.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Three Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 3 VSM | .50 | .32 | I | .46 | |
| 5 ASM | .77 | .11 | V | .62 | |
| Eigenvalue 1.1029 | | | | | |
| % Var acct'd for by Factor 11 | | | | | 59% |

[a]Five factor solution

[b]N = 305

TABLE 11

**Factor V.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Three Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communal-ity | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 AR | .58 | .38 | IV | .52 | |
| 2 VR | .75 | .14 | IV | .53 | |
| 4 AA | .49 | .47 | IV | .63 | |
| 6 VA | .63 | .24 | I | .51 | |
| 7 VC | .62 | .39 | I | .56 | |
| Eigenvalue 1.0210 | | | | | |
| % Var acct'd for by Factor 14 | | | | | 59% |

[a]Five factor solution

[b]N = 305

The other four variables, Auditory Reception, Visual Reception, Visual Associations, and Visual Closure, also clustered together in the separate ITPA analysis. In addition, the sub-test variable, Grammatic Closure, while it did not have a factor loading sufficiently large for interpretation here, did associate with these variables in the subsequent analyses of the ITPA. The association of Grammatic Closure with this set of variables probably means it should be considered part of Factor V. It is assumed that these six sub-test variables of the ITPA probably comprise the Auditory-Visual Understanding factor identified here.

In summary, the five factor solution presented here probably describes the clustering of these 17 sub-tests in the most parsimonious manner. The acceptance of this solution has much to recommend it empirically because all the factor analytic criteria were met in this solution.

Factor Analyses: The ITPA

The following analysis yielded a three-factor solution for the ten ITPA sub-test variables. The ITPA intercorrelation matrix was submitted to Principal Axis Factor Analysis with Varimax Rotation.[1] The number of factors to be rotated was determined by an eigenvalue of 1.000. The three factor solution accounted for 59% of the factor variance and each

[1] See Appendix 1.

factor contributed at least 17% of the factor variance (Table 12). This solution was also consistent with the Three-Test solution just presented which showed the ITPA sub-test variables loading on three factors (Tables 12-15).

The third factor presented below has an eigenvalue of .9879 which is slightly below the criterion for determining the number of rotated factors used for interpretation. Because this three-factor solution was consistent with the previous discussion of the Three-Test Battery, this factor was interpreted.

Table 13 presents Factor I, Auditory-Visual Understanding, which had six variables loading on it. The sub-test, Visual Reception had a factor loading of .66 and Visual Association had a factor loading of .68. Visual Closure had a factor loading of .75 associated with Factor I above. The remaining three sub-tests, Auditory Reception, Auditory Association, and Grammatic Closure had factor loadings of .56, .56, and .50, respectively, with Factor I. These same six variables clustered together on the same factor throughout all analyses. Without exception, the three sub-tests, Auditory Reception, Auditory Association, and Visual Association, clustered together in each analysis. The Visual Reception and Visual closure sub-tests had factor loadings associated with the three sub-tests above on all the analyses except one. On the Four-Test analysis, Visual Reception and Visual Closure, did not cluster with the variable set above;

TABLE 12

**Varimax Rotation Factor Loadings of All Variables for the ITPA on a Three Factor Solution.[a]**

| | Factors | | |
|---|---|---|---|
| Variables | I | II | III |
| 1 AR | .56 | | |
| 2 VR | .66 | | |
| 3 VSM | | | .55 |
| 4 AA | .56 | | |
| 5 ASM | | | .87 |
| 6 VA | .68 | | |
| 7 VC | .75 | | |
| 8 VE | | .85 | |
| 9 GC | .50 | | |
| 10 ME | | .84 | |
| Eigenvalues | 3.6111 | 1.2642 | .9879 |
| % Var accounted for by Factor | 24 | 17 | 17 |
| Total Variance accounted for by Three-Factor Solution 59% | | | |

[a]N = 305

TABLE 13

**Factor I.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the ITPA Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communal-ity | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 AR | .56 | .38 | III | .49 | |
| 2 VR | .66 | .11 | III | .45 | |
| 4 AA | .56 | .51 | III | .64 | |
| 6 VA | .68 | .19 | II | .51 | |
| 7 VC | .75 | -.07 | II | .57 | |
| 9 GC | .50 | .46 | III | .53 | |
| Eigenvalue | 3.6111 | | | | |
| % Var acct'd for by Factor | 24 | | | | 59% |

[a]Three factor solution

[b]N = 305

however, they did load together on another factor. The final sub-test variable, Grammatic Closure, did not load on the Three-Test analysis, but it was consistently associated with this variable set in the remaining two analyses.

Two sub-tests comprised Factor II, Verbal-Manual Expression (Table 14). Both of these variables, Verbal Expression and Manual Expression, had strong factor loadings on this factor. The former was .85 and the latter was .84. It was noted previously that this variable set was probably the most stable one occurring in the present study, because these variables were associated together on all analyses and they had high factor loadings on Factor II.

The sub-tests, Auditory Sequential Memory and Visual Sequential Memory, were associated with Factor III, Serial Learning (Table 15). The variable, Auditory Sequential Memory, had a factor loading of .87 on this factor, and Visual Sequential Memory had a factor loading of .55. The decision to interpret this factor despite its eigenvalue of .9879 was based upon three reasons in addition to the one cited previously. First, both of these sub-tests, Auditory Sequential Memory and Visual Sequential Memory, did not have sufficiently large factor loadings on the Four-Test analysis to include them for interpretation. However, on all other analyses they associated together with one factor. Second, it was pointed out previously that these sequential memory variables appeared to be measuring the same ability in terms of the ITPA theoretical model presented in Chapter I. Finally,

TABLE 14

**Factor II.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the ITPA Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 8 VE | .85 | .15 | III | .76 | |
| 10 ME | .84 | .11 | I | .72 | |

Eigenvalue 1.2642

% Var acct'd for by Factor 17 59%

[a]Three factor solution

[b]N = 305

TABLE 15

**Factor III.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the ITPA Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 3 VSM | .55 | .27 | II | .44 | |
| 5 ASM | .87 | -.09 | II | .76 | |
| Eigenvalue | .9879 | | | | |
| % Var acct'd for by Factor | 17 | | | | 59% |

[a]Three factor solution

[b]N = 305

the two analyses on which this serial learning dimension appeared were based upon data from 305 Ss. The factor loadings based upon the large sample were more stable than the loadings obtained from the other analyses. In view of these considerations, Factor III, Serial Learning, was retained.

In summary, the three factor solution for the ITPA sub-test variables has demonstrated dimensions which show stability and consistency across all analyses and a strong variable association with the respective factors presented above.

Factor Analyses: The DTVP

The DTVP intercorrelation matrix was submitted to Principal Axis Factor Analysis with Varimax Rotation as were the previous analyses.[1] All relevant criteria for suitable analysis were met by the data. One important exception was that a two-factor solution was presented in Tables 16-18 but the interpretation was that the variables show a unidimensional nature.

Four Frostig sub-test, Eye-Motor Coordination, Figure-Ground, Position in Space, and Spatial Relations, comprised Factor I, Visual Perceptual Relations (Table 17). Eye-Motor Coordination had a factor loading of .80 and Spatial Relations had a factor loading of .75. Both of these variables appeared to have a strong association with this factor. The remaining two variables, Figure-Ground and Position in Space, had moderate factor loadings of .66 and .63 respectively.

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[1]See Appendix 1.

TABLE 16

Varimax Rotation Factor Loadings of All Variables for the DTVP on a Two-Factor Solution.[a]

| | Factors | |
|---|---|---|
| Variables | I | II |
| 1 EMC | .80 | |
| 2 FG | .66 | |
| 3 FC | | .89 |
| 4 PIS | .63 | |
| 5 SR | .75 | |
| Eigenvalues | 2.4398 | .8662 |
| % Var Accounted for by Factor | 41 | 26 |
| Total Variance accounted for by Two-Factor Solution | | 66% |

[a]N = 305

TABLE 17

**Factor I.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the DTVP Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 EMC | .80 | -.21 | II | .68 | |
| 2 FG | .66 | .44 | II | .62 | |
| 4 PIS | .63 | .32 | II | .50 | |
| 5 SR | .75 | .38 | II | .70 | |
| Eigenvalue 2.4398 | | | | | |
| % Var acct'd for by Factor 41 | | | | | 66% |

[a]Two factor solution

[b]N = 305

These two sub-tests and the Spatial Relations sub-test had secondary factor loadings which indicated a mild association with Factor II of this solution. This was taken to mean that their nature would become clearer if these two DTVP factors were collapsed together. In addition, it must be noted that all five Frostig sub-tests were associated with one factor in the Three-Test analysis previously presented. This evidence appeared to support the assumption that this testwas unifactorial in nature. Further evidence is presented in the Four-Test analysis on which Form Constancy, the variable that comprised Factor II of this solution, did not load with any factor.

Factor II, Form Constancy, was associated with the Form Constancy sub-test (Table 18). The factor loading for this variable was .89. However, the decision to interpret the Frostig variables as a unidimensional set was determined by the eigenvalue associated with this factor which was .8662. This latter figure was considerably below the cut-off value of 1.000. Furthermore, it has been noted that a factor with only one loading is difficult to interpret. Ideally, at least two variables should load on a factor before that factor can be interpreted.

To summarize, the analysis of the DTVP revealed that this test was unidimensional. This interpretation was consistent with that suggested in the research review presented in Chapter I.

TABLE 18

**Factor II.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the DTVP Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 3 FC | .89 | .10 | I | .81 | |
| Eigenvalue .8662 | | | | | |
| % Var acct'd for by Factor 26 | | | | | 66% |

[a]Two factor solution

[b]N = 305

Factor Analyses: Four-Test Battery

The results of the factor analysis for the Four-Test Battery are presented in Tables 19-28. It appeared that the best solution was a nine factor one where these nine factors accounted for 64% of the factor variance. Every factor, except Factor IX, had one variable with a factor loading of .70 (Table 19).

The four test analysis was performed in the same manner as the preceding.[1] All the criteria for factor analysis were met with the single exception being that of the subject-variable ratio criterion. However, these data were considered important enough to include despite the failure to meet the sample size.

Three PPMS sub-tests comprised Factor I, Body Coordination (Table 20). They were Walking Board, Kraus—Weber, and Angels-in-the-Snow. Two of the variables, Walking Board and Angels-in-the-Snow were strongly associated with the factor and had respective factor loadings of .71 and .77. The remaining variable, Kraus-Weber, had a factor loading of .63. The interpretation of this set of sub-test variables was difficult to make without the subsequent separate PPMS factor analysis also being considered. The latter analysis has shown the Kraus-Weber and Angels-in-the-Snow variables continuing to associate in a more interpretable factor. The Walking Board sub-test associated with another set of variables which was also more amenable to interpretation. Despite the magnitude of the factor loadings associated with this factor it was

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[1]See Appendix 1.

TABLE 19

**Varimax Rotation Factor Loadings of All Variables for Four Tests on a Nine Factor Solution.[a]**

| Variables | | Factors | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII | IX |
| 1 | AR | | .69 | | | | | | | |
| 2 | VR | | | | | | | | -.53 | |
| 3 | VSM | | | | | | | | | |
| 4 | AA | | .79 | | | | | | | |
| 5 | ASM | | | | | | | | | |
| 6 | VA | | .49 | | | | | | | |
| 7 | VC | | | | | | | | -.78 | |
| 8 | VE | | | .64 | | | | | | |
| 9 | GC | | .72 | | | | | | | |
| 10 | ME | | | .76 | | | | | | |
| 11 | EMC | | | | | .77 | | | | |
| [b]12 | FG | | | | | | | | | |
| [c]13 | FC | | | | | | | | | |
| 14 | PIS | | | | | | | .80 | | |
| 15 | SR | | | | | | | .59 | | |
| 16 | DIFF | | | -.54 | | | | | | |
| 17 | SAME | | | | .72 | | | | | |
| 18 | WB | .71 | | | | | | | | |
| [d]19 | J | | | | | | | | | |
| 20 | IBP | | | | | | -.80 | | | |
| 21 | IM | | | | | | | | | .62 |
| 22 | OC | | | | | | | | | .59 |
| 23 | KW | .63 | | | | | | | | |
| 24 | AIS | .77 | | | | | | | | |
| 25 | CB | | | | | | -.52 | | | |
| 26 | RW | | | | | | | | | |
| 27 | OP | | | | .71 | | | | | |
| 28 | VAF | | | | | | -.69 | | | |
| Eigenvalues | | 5.369 | 2.029 | 2.002 | 1.603 | 1.492 | 1.427 | 1.183 | 1.105 | 1.066 |
| % Var acct'd for by Factor | | 7 | 11 | 7 | 7 | 6 | 8 | 8 | 6 | 5 |
| Total Variance accounted for by Nine Factor Solution 64% | | | | | | | | | | |

[a]N = 93

[b]This Variable did not load above .50 on any factor.

[c]This Variable did not load above .50 on any factor.

[d]This Variable did not load above .50 on any factor.

TABLE 20

**Factor I.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 18 WB | .71 | .28 | IV | .72 | |
| 23 KW | .63 | .32 | IX | .66 | |
| 24 AIS | .77 | .18 | VIII | .71 | |
| Eigenvalue 5.3694 | | | | | |
| % Var acct'd for by Factor 7 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

assumed that the solution offered by the separate PPMS factor analysis was probably the more interpretable one. The reason for this was the simplicity of interpretation and the continued association of the Kraus-Weber and Angels-in-the-Snow sub-tests in that solution.

Table 21 shows four ITPA sub-test variables associated with Factor II, Auditory-Visual Understanding. These sub-tests were Auditory Reception, Auditory Association, Visual Association, and Grammatic Closure. The second and fourth variables were strongly associated with this factor, and their factor loadings were .79 and .72 respectively. Auditory Reception had a substantial factor loading of .69 associated with Factor II but the remaining variable, Visual Association, had a factor loading of .49 which was just below the .50 level used in this study to interpret a factor. However, as has been pointed out in the previous analyses of the Three-Test Battery and the ITPA, these variables clustered together consistently.

Three sub-test variables were associated with Verbal-Manual Expression, Factor III, of this solution (Table 22). Two of these variables demonstrated a strong and consistent association on the same dimension. These variables were the ITPA sub-tests, Verbal Expression and Manual Expression. The former had a moderate factor loading of .64 associated with this factor, and the latter had a fairly strong factor loading of .76. The final variable which appeared to be related to Factor III was the Wepman Sub-test, DIFFERENT word-pairs, with a factor loading of .54.

TABLE 21

**Factor II.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 AR | .69 | .35 | VIII | .67 | |
| 4 AA | .79 | .25 | I | .74 | |
| 6 VA | .49 | .28 | III | .56 | |
| 9 GC | .72 | .17 | VII | .61 | |
| Eigenvalue 2.6286 | | | | | |
| % Var acct'd for by Factor 11 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

TABLE 22

Factor III.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communal-ity | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 VE | .64 | .40 | II | .72 | |
| 10 ME | .76 | .23 | II | .68 | |
| 16 DIFF | -.54 | -.38 | IV | .68 | |
| Eigenvalue 2.0020 | | | | | |
| % Var acct'd for by Factor 7 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

In the previous discussion of the Three-Test analysis, the two Wepman sub-tests loaded together. Because of the consistent association of the first two variables, Verbal Expression and Manual Expression, it appeared that the association of the present three variable set was due to the relatively small sample size employed in the Four-Test analysis.

The other Wepman sub-test variable, SAME word-pairs, and a PPMS variable, Ocular Pursuits, were related with Factor IV, Recognition of Sameness (Table 23). The associated factor loadings were .72 and .71 respectively. Although these factor loadings were strong ones, the variables appeared to be less related when the separate PPMS and Three-Test Analyses were considered.

The Wepman variable SAME word-pairs, associated with its opposite sub-test in the Three-Test analysis. This seemed to be the most fruitful explanation for the factor association of the variable set.

The Ocular Pursuits sub-test in the PPMS analysis, presented next, associated with three other sub-tests and offered a logical explanation for their association. Like the Factor III above, this dimension, Factor IV, seemed to be the result of the relatively small number of subjects employed in the present analysis.

The Frostig sub-test, Eye-Motor Coordination, was associated with a univariable dimension, Factor V, which was labelled Eye-Motor Coordination (Table 24). Its factor loading was .77, but since only a single variable loaded on this factor interpretation is difficult. Previous analyses have shown this DTVP variable

TABLE 23

Factor IV.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 17 SAME | .72 | .37 | II | .70 | |
| 27 OP | .71 | .25 | IX | .67 | |
| Eigenvalue 1.6027 | | | | | |
| % Var acct'd for by Factor 7 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

TABLE 24

**Factor V.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 11 EMC | .77 | .14 | VII | .65 | |
| Eigenvalue 1.4915 | | | | | |
| % Var acct'd for by Factor 6 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

to be related to a unidimensional factor comprised of the other DTVP variables.

Three PPMS variables, Identification of Body Parts, Chalkboard, and Visual Achievement Forms, loaded on Factor VI, Visual Body Orientation (Table 25).

The first sub-test, Identification of Body Parts had a strong factor loading of .80 associated with this factor. In the PPMS analysis, presented next, Identification of Body Parts was associated with two other PPMS variables which appeared to offer a more suitable interpretation for the factorial nature of this variable.

The other two PPMS sub-tests related to Factor VI, Chalkboard and Visual Achievement Forms, had factor loadings of .52 and .69 associated with Factor VI. These two variables, in the separate PPMS analysis, were related to two other sub-tests which presented a logical and interpretable variable set. One reason for assuming the separate PPMS factor analysis yielded a better factor interpretation was that the number of Ss used approximated the subject-variable ratio criterion previously discussed.

Factor VII, a spatial relations dimension, had two DTVP variables related to it. These were the Position in Space sub-test and the Spatial Relations sub-test (Table 26). The former was strongly associated to the dimension with a factor loading of .80, while the latter had a factor loading of .59. The association of these two variables, Position in Space and

TABLE 25

**Factor VI.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 20 IBP | .80 | .17 | II | .72 | |
| 25 CB | .52 | .40 | I | .71 | |
| 28 VAF | .69 | .29 | VII | .63 | |
| Eigenvalue 1.4270 | | | | | |
| % Var acct'd for by Factor 8 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

TABLE 26

Factor VI.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communal-ity | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 14 PIS | .80 | .15 | II | .69 | |
| 15 SR | .59 | .46 | V | .64 | |
| Eigenvalue 1.1831 | | | | | |
| % Var acct'd for by Factor 8 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

Spatial Relations, was confirmed by the Three-Test and DTVP analyses previously discussed. The Four-Test solution did not load two other DTVP variables, Figure-Ground and Form Constancy, in this factor analysis. It was noted that Eye-Motor Coordination, the remaining DTVP sub-test, appeared to be a univariable dimension associated with Factor V of this solution. The omission of two sub-tests and separation of Eye-Motor Coordination in this solution suggested that the best factorial association of these five variables was to be found elsewhere. This assumption strengthened the earlier conclusion that this set of variables was factorially associated.

Two associated ITPA variables, Visual Reception and Visual Closure, comprised Factor VIII, Visual Understanding (Table 27). Visual Closure had a strong factor loading of .78 associated with this dimension. The other sub-test, Visual Reception, had a factor loading of .53. These two variables were consistently associated in the previous analyses, and although the remaining variables generally associated with them were not loaded on this factor, the consistency of their related status could not be disregarded. Factor VIII seemed to support the belief that these two variables were substantially associated.

The final factor in this Four-Test solution was comprised of PPMS variables, Imitation of Movements and Obstacle Course. Factor IX, limb-trunk control (Table 28), was the only factor in the present nine factor solution which had variables associated with it that did not load in excess of .70. Imitation

TABLE 27

Factor VIII.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 2 VR | .53 | .45 | II | .57 | |
| 7 VC | .78 | .12 | I | .66 | |
| Eigenvalue 1.1054 | | | | | |
| % Var acct'd for by Factor 6 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

TABLE 28

Factor IX.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on Four Tests.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communal-ity | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 21 IM | .62 | .32 | V | .62 | |
| 22 OC | .59 | -.26 | V | .52 | |
| Eigenvalue 1.0657 | | | | | |
| % Var acct'd for by Factor 7 | | | | | 64% |

[a]Nine factor solution

[b]N = 93

of Movements had a factor loading of .62, while Obstacle Course had a factor loading of .59. In addition, the PPMS analysis also showed Imitation of Movements and Obstacle Course loading on different dimensions. While the loadings of these variables on their respective factors were not high in the PPMS analysis, they were interpretable. This was not the case in the present analysis. Again, the separate PPMS analysis was the most valid, in that it approached the subject-ratio criterion proposed in Chapter II, and the variables associated with the factors were interpretable.

The factor solution for the Four-Test Battery yielded nine factors from the 28 variables. This solution appeared to best describe the factor structure of the battery. However, the interpretation was limited by the difficulties which have been discussed. An increase in the sample size would have resulted, in all probability, in a shift in the factorial composition to conform with the previous analysis of the Three-Test Battery.

Factor Analyses: The PPMS

The PPMS factor analysis which is presented in Tables 29-33 was performed in the same manner as the preceding analyses. The intercorrelation matrix for the eleven subtest variables was submitted to Principal Axis Factor Analysis with Varimax Rotation.[1] The eigenvalue criterion for

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[1]See Appendix 1.

determining the number of factors to be rotated was, again, 1.000. Each factor which resulted from the four factor solution had at least one variable associated with it that loaded in excess of .70 (Table 29). The total factor variance accounted for was 62%. Each dimension accounted for a share of the factor variance which exceeded 10%.

As with the Four-test analysis, the subject-variable ratio criterion was not met. However, because of the reduction of variables in the intercorrelation matrix, the resultant analysis approximates this criterion. At least 110 Ss were needed to meet the minimum requirements of this factor analysis, but only 93 Ss were included. However, the solution presented here probably offers a better explanation of the factorial nature of the eleven sub-test variables than did the previous analysis because it did approximate the requirements for an adequate number of subjects.

The Kraus-Weber and Angels-in-the-Snow sub-tests loaded Factor I, Trunk-Limb Coordination (Table 30). They both had strong factor loadings of .80 on this factor, and both were also associated in the Four-Test analysis. The strength and consistency of the association of these variables seemed to indicate that these variables were related to the same underlying dimension, although a final conclusion about their factorial nature should await a more rigorous analysis.

The variables, Jumping and Obstacle Course, were related to Factor II, Muscle Control (Table 31). Jumping was strongly associated because its factor loading was .77, while the

TABLE 29

**Varimax Rotation Factor Loadings of All Variables for the PPMS on a Four Factor Solution.[a]**

| | Factors | | | |
|---|---|---|---|---|
| Variables | I | II | III | IV |
| 1 WB | | | .55 | |
| 2 J | | .77 | | |
| 3 IBP | | | .72 | |
| 4 IM | | | .49 | |
| 5 OC | | .64 | | |
| 6 KW | .80 | | | |
| 7 AIS | .80 | | | |
| 8 CB | | | | .74 |
| 9 RW | | | | .62 |
| 10 OP | | | | .76 |
| 11 VAF | | | | .51 |
| Eigenvalues | 3.3502 | 1.3309 | 1.0829 | 1.0279 |
| % Var accounted for by Factor | 17 | 14 | 12 | 18 |
| Total Variance accounted for by Four Factor Solution | | | | 62% |

[a]N = 93

TABLE 30

Factor I.[a] Principal Axis Factor Analysis with Varimax Rotation for All Variables on the PPMS Test.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 6 KW | .80 | .12 | IV | .65 | |
| 7 AIS | .80 | .23 | II | .71 | |
| Eigenvalue 3.3502 | | | | | |
| % Var acct'd for by Factor 17 | | | | | 62% |

[a]Four factor solution

[b]N = 93

TABLE 31

Factor II.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the PPMS Test.[b]

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 2 J | .77 | .12 | I | .63 | |
| 5 OC | .64 | .09 | III | .42 | |
| Eigenvalue 1.3309 | | | | | |
| % Var acct'd for by Factor 14 | | | | | 62% |

[a]Four factor solution

[b]N = 93

Obstacle Course variable had a factor loading of .63. These two variables presented a difficult interpretation problem in the Four-Test analysis. The first variable, Jumping, failed to load above .50 on any factor, but its association with Factor II seemed to indicate a relationship. The Obstacle Course variable became more interpretable in this solution. Both variables appeared to be logically associated in this analysis and were easier to interpret in this solution.

Factor III, Body Balance Orientation (Table 32), had Walking Board, Identification of Body Parts, and Imitation of Movements associated with it. Identification of Body Parts had a factor loading of .72. The Walking Board had a loading of .55, but the last variable, Imitation of Movements, had a factor loading of .49. Imitation of Movements loaded with the Obstacle Course variable on the Four-Test analysis but as noted above, the latter sub-test had a substantial factor loading on Factor II. The separation of these two variables made interpretation easier because they appeared to be logically associated in this solution. The three variables, Walking Board, Identification of Body Parts, and Imitation of Movements, associated on Factor III. All involved balance and body orientation in a vertical plane. The sub-test descriptions from Chapter I supported this observation.

The final four sub-tests of the PPMS appeared to be related to Factor IV, Visual Reproducibility (Table 33). The sub-tests, Chalkboard and Ocular Pursuits, had factor loadings

TABLE 32

**Factor III.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the PPMS Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 1 WB | .55 | .41 | IV | .75 | |
| 3 IBP | .72 | .31 | II | .65 | |
| 4 IM | .49 | .46 | I | .50 | |
| Eigenvalue 1.0829 | | | | | |
| % Var acct'd for by Factor | | | | | 62% |

[a]Four factor solution

[b]N = 93

TABLE 33

**Factor IV.[a] Principal Axis Factor Analysis with Varimax Rotation for all Variables on the PPMS Test.[b]**

| Variable | Factor Loading | Variable's Next High Factor Loading | Factor of Next High Loading | $h^2$ Communality | Total Var acct Factor Solution |
|---|---|---|---|---|---|
| 8 CB | .74 | .29 | I | .65 | |
| 9 RW | .62 | .43 | I | .63 | |
| 10 OP | .76 | .19 | II | .62 | |
| 11 VAF | .51 | .43 | II | .59 | |
| Eigenvalue 1.0279 | | | | | |
| % Var acct'd for by Factor | 18 | | | | 62% |

[a]Four factor solution

[b]N = 93

of .74 and .76, respectively, on this factor. Rhythmic Writing had a factor loading of .62 associated with Factor IV. The final variable, Visual Achievement Forms, had a factor loading of .51. The Chalkboard and Visual Achievement Forms were associated in the Four-Test analysis. Ocular Pursuits in a previous analysis loaded on a factor with a Wepman variable. In this analysis, it presented a stronger association. Rhythmic Writing did not load in excess of .50 in the Four-Test solution. It appeared that this set of four sub-tests presented a more reasonable factor association because all these variables involved visual tasks. This fact seemed to account for the apparent association among these variables.

The 11 sub-test variables of the PPMS best fit the four factor solution presented above. This solution was more economical than the one discussed in the research review.[1] It should be recalled that the authors maintained that the PPMS items were not factorially pure (Chapter I), and tentative acceptance of this factor solution provided a PPMS dimensional model which was not available before.

Factor Analyses: Summary

A tabular summary of the dimensions found in this study is presented in Table 34.

The WADT was not submitted to separate factor analysis, because it was felt that a test with only two generated sub-tests was not amenable to factor analysis. Furthermore, the character of the two generated sub-tests were such that it

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[1]See Appendix 2.

TABLE 34

A Summary of the Factor Structure of the Four Tests

| Factor Name and Associated SI Code | Common Name | Associated Sub-Test Variables |
|---|---|---|
| 1. Auditory Visual Understanding. Cognition of Semantic Relations (CMR) | Semantic Relations | Auditory Reception, Visual Reception, Auditory Association, Visual Closure, Visual Association, Grammatic Closure. |
| 2. Verbal Manual Expression. Convergent Productions of Semantic Relations (NMR) | Semantic Correlates | Verbal Expression, Manual Expression. |
| 3. Serial Learning. Memory for Symbolic Systems (MSS) | | Auditory Sequential Memory, Visual Sequential Memory. |
| 4. Visual Perceptual Relations. Cognition of Figural Systems (CFS) | Spatial Orientation | Eye-Motor Coordination, Figure-Ground, Form Constancy, Position in Space and Spatial Relations. |
| 5. Auditory Discrimination. Evaluation of Symbolic Units (ESU) | Symbolic Identification | Wepman Auditory Discrimination Test. |
| 6. Trunk-Limb Flexibility and Strength | | Kraus-Weber, Angels-in-the-Snow. |
| 7. Limb Impulsion and Gross Coordination | | Jumping, Obstacle Course. |
| 8. Limb and Gross Precision | | Walking Board, Identification of Body Parts, and Imitation of Movements. |
| 9. Visual Reproducibility. Memory for Figural Units (MFU) | Visual Memory | Chalkboard, Rhythmic Writing, Ocular Pursuits, and Visual Achievement Forms. |

appeared they were measuring the same factor. The assumption that the WADT was unidimensional was based upon inspection of the Four-Test and Three-Test analysis. In the former analysis, the two WADT sub-test variables, DIFF and SAME, loaded on separate factors which were difficult to interpret (Tables 7 and 8). When reanalyzed in the Three-Test case, these two variables loaded on the same factor (Table 17). Also, the variables that were associated with these two in the Four-Test analysis presented a clearer factor structure after being separated from the WADT sub-test variables (Tables 16 and 24). It was assumed that the WADT was a unifactorial test of auditory discrimination.

The analyses showed the ITPA best fits a three-dimensional model. When each analysis was compared, three associated variable sets appeared consistently: (a) the Auditory Reception, Auditory Association, Grammatic Closure, Visual Reception, Visual Association, and Visual Closure sub-tests were on one dimension; (b) the Auditory and Visual Sequential Memory sub-tests were on another dimension; and (c) the Verbal Expression and Manual Expression sub-tests were on the third dimension. It was assumed that the ITPA was a three dimensional test. These dimensions were auditory-visual comprehension, auditory-visual serial learning, and verbal-manual expression.

In the separate analyses, the DTVP yielded fairly consistent results. Despite its loading on the final analysis as a

two dimensional test, the most satisfactory assumption was that the DTVP was a unidimensional test of visual perception. This decision represented the best explanation of the three factor analyses in which the DTVP was a part.

The analysis of the PPMS suffered from a failure to meet the subject-variable ratio criterion, because only 93 Ss were administered this test. Despite this shortcoming, several similarities between the Four-Test analysis and the separate PPMS analysis presented above led to the conclusion that the PPMS was a four-dimensional test. The Four-Test analysis indicated the PPMS loaded on four factors, three of which contained two variables that were associated in the separate PPMS analysis. The latter result produced the most acceptable solution. The abilities associated with those four dimensions were: (a) trunk strength and limb flexibility in a horizontal plane; (b) limb impulsion and gross coordination; (c) limb and gross precision in a vertical plane; and (d) visual coordination and reproducibility. These abilities provided the best labels for the factors.

It was apparent that the factorial structure underlying this battery of tests was best represented by nine dimensions. These nine factors appeared to provide a parsimonious explanation of the underlying dimensions of the 28 sub-test variables, because the latter were consistent and easily interpreted across the analyses. Finally, because the sample was fairly large,

these results were quite stable.

Two-Way Analysis of Variance: Age and Sex

Tables 35 and 36 present the results of a two by three analysis of variance for sex and age effects. Factor scores for each of five dimensions were derived from the Three-Test Solution which was chosen because it appeared to best represent the factorial nature of the sub-test variables. The DTVP and the WADT were unidimensional tests while the ITPA was tridimensional. The ITPA's first dimension was comprised of the Reception, Association, and Closure sub-tests. The Verbal and Manual expression sub-tests loaded on another dimension while the third factor loaded the Sequential Memory variables. The use of standard scores for analysis of variance does not affect the results as Nunnally (1967 points out, because, "...the results of a particular analysis of variance would be the same whether the analysis started with raw scores, deviation scores from the grand mean, or standard scores from the grand mean. The different ratios of variance would be the same regardless of which type of scoring was used" (p. 106).

Factor scores are standardized scores ($\overline{X}$=0, s.d.=1) based upon the weighted contribution of each sub-test to a particular factor. This weighing is a function of the measure of associ-

ation of a given item (the rotated factor loading). In general, the higher the factor loading for a particular item the stronger its association with the factor and the more it contributes to the factor score. Factor scores allow the researcher to treat these underlying dimensions as variables and their weighted scores as variable scores.

Guilford (1954) in discussing experimental controls for factor analysis observed that, "...It is good practice to control on the very common variables of age, sex, and educational level" (p. 528). The analysis of variance was performed to determine the extent to which experimental controls were present in this study. In addition, the ITPA and the DTVP are presumed to show developmental differences and it was expected that differences would be obtained over the 18-month age range of the sample.

The sample of 301 Ss was divided into three groups by age, beginning with 60 months. These groups were 60-65 months, 66-71 months, and 72-77 months. Four Ss who were over 77 months of age were excluded.

Of the 15 comparisons in the analysis of variance, only three (Tables 35 and 36) had F-Ratios which were significant at the .05 level. The second, third, and fourth factors apparently were unaffected by sex and age effects. This indicated that the WADT test results were not influenced by sex and age differences in this sample. Also, the ITPA sub-test variables associated with the serial learning and verbal manual expression factors were not influenced by sex and age. If these

ITPA sub-tests were designed to yield differential results at these age levels, these effects were not present. Consequently, the usefulness of age norms for the sub-tests associated with these factors on disadvantaged children was brought into question.

Factor 1 in Table 35 had an F-Ratio which was significant for age effects. In order to determine which age levels differed significantly, post hoc comparisons of means were performed using the Scheffé method (Hays, 1963). Each cell mean was compared with all other cell means, and three individual comparisons were performed. Of these three, the comparison of means between Cell 1 (60-65 months) and Cell 3 (72-77 months) was significant. These results indicated that differences on the DTVP sub-test variables occurred only among Ss differing in age by twelve months.

Factor 5, which had the reception, association, and closure sub-tests of the ITPA associated with it, had two significant F-Ratios for age and sex main effects (Table 36).

The F-Ratio for sex showed that the females differed significantly from the males. It is possible that this difference can be attributed to either item bias in the sub-tests or to basic developmental differences. Considering the fact that language differences have been observed between sexes, especially at this level, this is the most likely explanation for the observed difference. If this set of tasks from the ITPA does differentiate between males and females, the utility of norms based upon combined scores is questionable.

The second significant F-Ratio of Factor 5 was for age. It too was submitted to a post hoc comparison of means, and

TABLE 35

Two-Way Analysis of Variance[a] for

Sex/Age for Factor 1.[b]

| | df | Mean Squares | F-Ratio |
|---|---|---|---|
| A - Sex | 1 | 1.20461444 | 1.8063 |
| B - Age | 2 | 2.19121325 | 3.2856[c] |
| AB | 2 | 0.61280292 | 0.9189 |
| Error Term | 295 | 0.66690463 | |
| Total | 300 | | |

[a]N = 301

[b]Alpha of $p<.05$ required for significance.

[c]Significant F-Ratio (.039).

TABLE 36

**Two-Way Analysis of Variance[a] for**

**Sex/Age for Factor 5.[b]**

| | df | Mean Squares | F-Ratio |
|---|---|---|---|
| A - Sex | 1 | 4.40911723 | 8.3567[c] |
| B - Age | 2 | 8.96763619 | 16.9965[d] |
| AB | 2 | 0.07484508 | 0.1419 |
| Error Term | 295 | 0.52761732 | |
| Total | 300 | | |

[a]N = 301

[b]Alpha of p<.05 required for significance.

[c]Significant F-Ratio (.004).

[d]Significant F-Ratio (<.005).

the results showed that the factor score means were significantly different across each pair of cells. It appeared that as age increased higher scores on the sub-tests for the older children could be expected. This result was consistent with expectations for children of different age levels. For this set of sub-tests, presumably the ITPA does differentiate between age groups. It appeared that age norms based upon the tasks associated with this factor did discriminate among the disadvantaged children in this sample.

To summarize the results of the analysis of variance for sex and age effects, 12 F-Ratios out of 15 were not significant. The ITPA sub-tests for sequential memory and verbal-manual expression as well as the WADT sub-tests represented by these non-significant F-Ratios were not affected by sex or age differences. There were three significant F-Ratios. Factor 1, which loaded the DTVP variables, had a significant age effect for Ss who were twelve months apart in age. Factor 5 presented significant main effects for both sex and age.

Multiple Regression Analyses: Least Squares Delete and Least Squares Add

The Least Squares Delete and Least Squares Add multiple regression analysis which follows was aimed at determining which of several independent variables would serve as the best predictor of I.Q.

In the Least Squares Delete program, when I.Q. was used as the criterion measure and the 17 sub-test variables of the Three-Test Battery were used as independent variables

the multiple correlation ($R^2$) for the full group before deletion of any variables was .68. From this set of variables, all sub-tests except Auditory Association, Auditory Sequential Memory, Grammatic Closure, and Spatial Relations, were deleted one at a time without a significant drop in $R^2$. The significance level was set at .05. With only Auditory Association, Auditory Sequential Memory, Grammatic Closure, and Spatial Relations left in the regression equation, the $R^2$ was .63. These four sub-test variables appeared to be significant contributors to the explained variance accounted for by this prediction equation.

The Least Squares Add multiple regression analysis yielded comparable results. For the Three-Test Battery, the first variable to be added was Auditory Association and the regression equation $R^2$ was .50. Spatial Relations was added next, increasing the $R^2$ to .58. This increase was significant beyond the .0005 level. Grammatic Closure was subsequently added with an $R^2$ increase to .61. The final variable added was Auditory Sequential Memory which increased the $R^2$ to .63. The computer program (MSU Agricultural Experiment Station, 1968) identified the same four sub-test variables as the Least Squares Delete program above.

These two identical solutions using the multiple regression formula to determine the best sub-set of predictors of I.Q. indicated that Auditory Association, Auditory Sequential Memory, Grammatic Closure, and Spatial Relations were the best predictors of this dependent variable.

CHAPTER IV

# DISCUSSION AND CONCLUSIONS

This final chapter presents a discussion of the relationship between the hypothesized factor structure predicted in Chapter I and the empirical factor structure presented in Chapter III. In addition, the limitations of this study implications of this study for future research, and a summary are presented.

## Hypothesis Confirmation: A Comparison of the Predicted Factor Structure and the Empirical Factor Structure

For the purpose of this study, the confirmation of an hypothesis was demonstrated by the degree to which a theoretically predicted set of variables belonging to a factor corresponded to the set of empirically determined variables. Further, such confirmation depended upon a psychologically sound explanation which provided a suitable rationale for the observed association of a set of variables. The confirmation or disconfirmation of the hypothesized factor structures presented several difficulties.

First, Guilford's Structure of Intellect model (Figure 3) upon which much of the predicted factor structure was based, although the best model available, does have a shortcoming. The model presents a set of ability dimensions which have been

obtained with adult Ss. However, this does not necessarily mean that those ability patterns will be matched by a child's model. Guilford (1966) noted that his SI model presented some difficulties when applied to the analysis of ability structures in children. Below the sixth grade level, there has been some differentiation of his ability factors but it appeared that their detection depended upon the level of maturity of the S. When the S possessed the maturity, the appropriate dimensional tests could be administered and Guilford's factors differentiated. It appeared that the prediction of ability dimensions in kindergarten Ss would be confounded by two things: the lack of accurate information regarding the structure of abilities for such Ss, and the possibility that the Ss do not possess sufficient maturity to differentiate the ability factors when tested with appropriate indices of those factors.

The second difficulty encountered in the confirmation of predicted factor structures involved the nature of the tasks in this set of sub-tests. The suitability of these sub-tests to differentiate the hypothesized factors was based upon a comparison of the sub-test tasks with the skills associated with Guilford's SI model. The sub-tests were then grouped according to the results of that comparison. Additional supporting evidence was derived from the research review. However, a real possibility exists that the tasks associated with this battery do not differentiate the dimensions posited by Guilford.

A third difficulty derived from the subjective decisions regarding interpretation of the factors. The factor labels were

based upon an idiosyncratic decision about how they best described the character of the underlying dimension.

A fourth difficulty lies in the studies chosen to support the hypothesized factor structure. Inherent in each of those studies were the same difficulties presented above. In addition, the nature of the results offered in those studies may have been unintentionally misinterpreted.

A comparison in tabular form of the hypothesized factor structure for this study and its empirical factor structure is presented in Figure 4. There is some incongruity between the two structures shown there. Seven hypothesized factors were not present in the data. Despite the reduced number of predicted dimensions appearing in the observed results, there was not a great shift in any of the variables predicted to associate with a factor. In general, the sub-tests were associated as predicted. It appeared that the major inconsistency between the two structures resulted from an over prediction of factors rather than from erroneous predictions among variables. This may have been caused by the aforementioned difficulties of interpretation. The remainder of the discussion presents what was presumed to be a logical explanation of the empirical factor structure in psychological terms so that the inconsistencies observed regarding this structure and the predicted factor structure should be mitigated.

The only factor which emerged as predicted was Factor 8 of the hypothetical structure, which was empirical Factor 5. The WADT sub-tests were predicted to load on an SI dimension

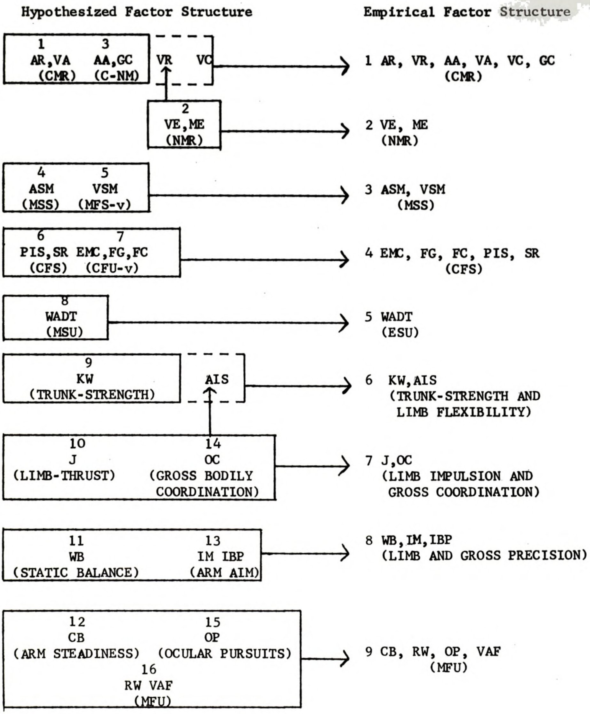



Figure 4. A Comparison of the Hypothesized Factor Structure[1] (HFS) and the Empirical Factor Structure (EFS).

[1]Broken lines show variables which shifted predicted factor. Boxes contain predicted factors which merged in empirical structure.

labelled Memory for Symbolic Units (MSU). This dimension is the ability to remember isolated items of symbolic information, such as syllables or words. Some tasks associated with this factor are memory for listed nonsense words or memory for nonsense words through free recall. The WADT sub-tests did associate with this factor.

A post hoc review of the SI abilities suggested a more appropriate classification for the WADT dimension to be Evaluation of Symbolic Units (ESU). This is the ability to make rapid decisions regarding the symbolic identity or accuracy of words, letter sets, and number sets. An example of the associated tasks which correlated with the latter factor was symbol identities. In this task, the S judged whether both members of pairs of words were the same or different. This task was similar to the task required by the WADT. It will be recalled that the WADT presented forty word-pairs to the S. Thirty of these were differentiated by one phoneme while the remaining ten word-pairs were the same. The S responded to the reading of these word-pairs by indicating which were the same and which were different. This test clearly required the same kind of skill as that required by the ESU ability, Symbolic Identification.

The inconsistencies between the ITPA hypotheses and the predicted factor structure appeared to be related to the ITPA theoretical model. Meyers (1968), whose review of ITPA factorial studies provided the basis for the ITPA predictions,

concluded that most of the studies he summarized had shown the auditory and visual channels of communication from the ITPA theoretical model to be the most useful for classifying the sub-test variables of the ITPA. As a result of his conclusion, the predicted factor structure of the present study stressed these two communication modes. However, the results of this study suggested an alternative solution to account for the fact that the empirical factors had their ITPA variables associated as they were.

In the present study, the ITPA's theoretical dimension, channels of communication was less significant than the psycholinguistic process dimension. The latter dimension specified the acquisition and use of the habits required for normal language accomplishments, and was comprised of the receptive, organization, and expressive psycholinguistic processes.

The first of these, reception, is concerned with how meaning is obtained from auditory or visual linguistic stimuli. The second process, organization, refers to the way in which linguistic symbols are processed internal to the organism. And the final process, expression, is concerned with how one expresses oneself in words or gestures.

In the empirical factor structure, the ITPA sub-tests appeared to form a single dichotomy. Those variables associated with either reception or organization loaded on empirical Factors 1 or 3, while those related to expression loaded on empirical Factor 2. In the data, this dichotomous separation by process suggested that the ITPA emphasized the psycholinguistic processes of reception and expression.

The explanation offered above suggested an altered ITPA model which obtained empirical support in this study. All three empirical factors loaded by ITPA variables were readily interpreted if the model dimension was rotated to an expression-reception dichotomy.

Empirical Factor 1, labelled Cognition of Semantic Relations (CMR), or semantic relations, is the ability to see relations between ideas or meanings of words. An example of a task associated with this dimension is verbal analogies. This task involves the completion of a meaningful semantic relationship.

The six variables associated with empirical Factor 1 represented the reception, association or organization, and closure sub-tests. The first two terms, reception and association, were defined above. Closure assessed the S's ability to integrate discrete verbal or visual units into a whole.

The first sub-test associated with this factor, Auditory Reception, required the S to give a "yes" or "no" response to a series of verbal questions. While not precisely a verbal analogy, this task did require the S to complete a meaningful verbal chain in order to be correct. Another sub-test related to empirical Factor 1, Auditory Association, required the S to complete a verbal analogy exactly as the SI task required.

A third sub-test, Grammatic Closure, required the S to respond to incomplete verbal statements after first viewing pictures which portrayed the content of the verbalizations.

This sub-test introduced a visual element, but its basic task was to assess the ability to see a relationship between ideas or meanings of words. Grammatic Closure is consistent with the nature of the semantic relations task described above.

The three visual sub-tests of the ITPA which appeared to be related to this factor may have loaded on it because the Ss in this study may have been incapable of differentiating the visual sub-tests. It will be recalled that this was one difficulty discussed in interpreting the factor structure.

It seemed that these three sub-tests, Visual Reception, Visual Association, and Visual Closure, required the Ss to see relationships of a semantic nature. For example, the Visual Closure sub-test required the S to identify an object (e.g. a dog picture), and then from a new picture the S was required to identify all partially hidden dogs in the picture. This task has implicit in it the necessity to perceive a relationship between the idea of a dog and a class of body parts associated with the concept dog. It seemed reasonable to assume that these relationships were mediated in semantic terms by the S. Once the object had been identified, the S might have employed the object's name as a mediator while identifying parts of the object.

The Visual Reception and Visual Association sub-tests presented highly similar tasks. In the former, the examiner presented a stimulus picture to the S, then the S was required to point to one of four pictures which was related (e.g. the stimulus picture was of a dog and one of the four response

pictures was of a different breed). The latter task, Visual Association, required the S to point out which of four pictures was most closely associated with a central theme (e.g. the central picture was of a dog and one of the four response pictures was of a bone). It is probable that a considerable semantic element operated during the decision-making process of the S. The ability to perceive relations either auditorially or visually seemed to be involved in all these tasks.

Factor 2 of the empirical factor structure was named Convergent Production of Semantic Relations (NMR). This factor involved a semantic dimension which related to the ability to produce a word or idea that conformed to specific relational requirements. An example of a task associated with this dimension was one requiring the S to produce a word that was similar in meaning to two other given words. This task, which required the generation of information from given information to produce a predetermined response, involved a type of convergent production ability.

The ITPA variables which related to Factor 2 were the two expression sub-tests. The first, Verbal Expression, required the S to describe an object which was handed him by the examiner. Correct responses were defined in terms of ten descrete categories. Some of these categories involved shape, color, composition, function, and numerosity. For example, the S was given an envelope and he would respond by saying that the object was an envelope, it was white, it was square, it was made of paper. Each of these responses

received credit when it belonged to a category.

The other expression sub-test, Manual Expression, required the S to look at a picture of an object and indicate with a gesture the activity involved in manipulating the pictured object. For example, the S performed a hammering action on the table after seeing a picture of a hammer. In both sub-tests it appeared that the S was being asked to produce a gesture or word that conformed to specified requirements. He was to generate information from given information (e.g. the sight of an envelope cued a set of related descriptive terms, or the hammer picture recalled the use to which a hammer was put).

Empirical Factor 3, Memory for Symbolic Systems (MSS), is the ability to remember the order of symbolic information. Tasks associated with this dimension included memory for transposition of digits, consonants, nonsense word span, and memory for order of listed numbers. These tasks all seemed to tap memory for symbolic sequences in both a visual and verbal mode. The two sequential memory sub-tests of the ITPA were related to this factor. They required either memory for visual symbolic sequences or verbal symbolic sequences.

Auditory Sequential Memory, it will be recalled, was a digit span task similar to those associated with this dimension. The S repeated a series of digits from two to seven in length in response to an auditory presentation of the digit sequence.

The Visual Sequential Memory sub-test required the S to replicate the order of a sequence of geometric figures after having been exposed to it for a short time. The position in

space of the figure was not important, only the sequential order was scored. This task appeared to be similar to the task related to empirical Factor 3 although it uses figural symbols rather than digits or consonants. It was possible that the Visual Sequential Memory sub-test loaded on empirical Factor 3 because it was purely figural.

Presumably, figural perceptions are developed before digit and consonant recognition, thus the task was within the ability level of the Ss in this sample. A similar task using digits or consonant which required the S to read digits would almost certainly be inappropriate for kindergarten Ss. This suggested that the Visual Sequential Memory sub-test may provide a useful alternative in testing non-readers for sequential memory. Further, it appears that if this ability dimension is to be differentiated in young Ss, an appropriate task to use might be a figural sequential memory task.

The decision to hypothesize two dimensions, Factors 6 and 7, for the DTVP sub-tests was based on apparent similarities between the test tasks and Guilford and Hoepfner's (1966) description of the SI tasks. However, the research review indicated that this test could be characterized as unidimensional. The interpretation of empirical Factor 4 in this study was quite clear. The DTVP was unidimensional.

Empirical Factor 4 appeared to be related to Guilford's Cognition of Figural Systems (CFS), a spatial orientation ability. CFS is the ability to comprehend arrangements and positions of

visual objects in space. Some of the tasks which load on this factor required the Ss: (a) To select from a group of six drawings of a card shown rotated and/or turned over, the ones which show the card not turned over, (b) To indicate from a stimulus cube which of two drawings of the cube are either of the same cube, or not the same cube judging from the markings on the faces of the cubes, and (c) To indicate the position of a boat with respect to the landscape after a pictured change in the boat's position. These three tasks tested the spatial orientation dimension.

The Frostig sub-test, Eye-Motor Coordination, is comprised of two tasks. First, the S is required to draw lines between progressively smaller boundaries. Second, the S is required to draw straight lines between two objects and to connect as many as three dots with straight lines between dot pairs. Presumably, this variable tests the hand-eye coordination of the S. However, it appeared that the required tasks were related to the spatial orientation tasks because drawing lines, whether curved or straight between boundaries or objects, did require the S to perceive accurately the orientation of the boundary or object with respect to the appropriate placement of his pencilled lines.

The second DTVP variable, Figure-Ground, required the S to draw lines around various geometric forms presented in a distracting background. The discrimination of these figures and their position in the distracting background appeared to couple the orientation of the particular form in its space with

the recognition of that form.

Form Constancy, the third DTVP sub-test, required the S to outline circles and squares presented in various orientations. In some cases there were squares within squares with the forms rotated into a different plane, or these forms were presented within unrelated geometric figures. It seemed that spatial orientation was an important concomitant of this task.

The Position in Space sub-test, the fourth DTVP variable, required the S to choose one of four objects which was either identically oriented in space to a stimulus object, or was oriented in the inverse plane (e.g. the S selected one table which was up-side down when all other tables shown are right-side up, or the S selected one of four snowmen which corresponded exactly to a stimulus snowman). Presumably, the relationship of this task to a spatial relations dimension was established here.

The final DTVP variable, Spatial Relations, required the S to reproduce on the left half of a page a stimulus form presented on the right half of that page. This was done by connecting a series of dots in exactly the same form outline and spatial orientation relative to the stimulus. Because this task is labelled spatial relations and seemed to test this ability, its association with the CFS dimension appeared to be a logical one.

In summary, this set of Frostig variables purported to test five unique abilities, but they seemed to be testing the spatial relations dimension described here. The discrepancy

between the predicted factor structure and the empirical factor structure appeared to have resulted from an unwarranted reliance upon the task descriptions presented by Frostig. These descriptions are found in Chapter I.

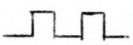
The hypothetical factor structure posited eight factors to explain the factorial nature of the PPMS. However, the empirical factor structure resulted in four factors which accounted for the PPMS factor structure.

Three predicted factors, 12, 15, and 16, merged to form empirical Factor 9. This seemed to be a cognitive ability dimension and was labelled Memory for Figural Units (MFU). The tasks related to this dimension were visual memory abilities. MFU is the ability to remember given figural objects. An example of the tasks related to the MFU dimension was reproduction of designs. In this task, the S reproduced geometric designs after having had a brief exposure to them.

The tasks related to the three factors which merged to form this MFU dimension were found in the following PPMS variables: Chalkboard, Rhythmic Writing, Visual Achievement Forms, and Ocular Pursuits.

The Chalkboard task required the S to draw a single circle across the midline of his body with one hand, draw two circles simultaneously, one with each hand, draw a horizontal line from right to left across his body midline, and draw vertical parallel lines one with each hand. These tasks presumably tested directionality and perceptual-motor match. However, the performance of these tasks required the S to be able to recall what the figure looked like before he could reproduce it.

The test instructions to the examiner stipulated that the task was not to be demonstrated. Also, it seemed that the performance of this task was conditioned by the maturity of the S. Inadequate maturity would preclude the completion of these tasks. It appeared that while these tasks tested perceptual-motor functioning, an important cognitive ability, MFU, was related to them.

Rhythmic Writing, another task which loaded on empirical Factor 9, presented directionality skills. The S copied written motifs (e.g. , *eeeeeee*, and *pbpbpb* ). Although there may be a motor coordination component associated with Rhythmic Writing, its successful completion required short term memory for a figure.

The Visual Achievement Forms variable of the PPMS tested the S's ability to reproduce, in proper perspective, geometric forms. This task tested more than one ability, because the geometric figures had to be reproduced in proportion to their size as well as being placed on the page so that all the figures could be drawn there. However, the reproduction of these geometric forms appeared primarily to be a visual memory task. It seemed that the ability to perform these tasks adequately required a memory skill to reproduce the figures and to dimensionalize them on the page so that all the figures were in the same perspective.

The final variable related to this dimension was Ocular Pursuits. This sub-test included various tasks in which the eye followed a penlight moved from right to left, up and down, and diagonally from left to right. These tasks tested both

monocular vision and binocular vision. This variable loaded on the MFU factor because all the variables loading on this factor have a visual component. It is possible that its high correlation with this factor resulted from the visual nature of the related tasks. The Ocular Pursuits variable might load on a different factor if the PPMS were factor analyzed with purely visual tests. Furthermore, the other PPMS variables seemed to demonstrate tasks which were represented by Guilford's MFU ability. These data suggested the presence of a cognitive dimension in the PPMS.

The three remaining PPMS empirical factors fit Guilford's Matrix of Psychomotor Abilities presented in Chapter I (Table I). The labelling of these factors resulted from the use of the marginal designations in that table. The designations which provided suitable classification categories for the psychomotor abilities were: (1) the part of the body involved and (2) the type of ability involved.

Empirical Factor 6, Trunk-Limb Flexibility and Strength, was comprised of the PPMS variables, Kraus-Weber and Angels-in-the-Snow. The factor label was derived from the trunk-strength and limb-flexibility marginals presented by the Psychomotor Abilities Index. Examples of the tasks associated with these marginals are leg raising and kicking-height. The first task, a trunk-strength ability, required the S to raise his leg to the height of his head while in a sitting position. In the kicking-height task, a flexibility skill, the S kicked as high in the air as he could. This demonstrates

his flexibility: the extent to which that part of his body is free to bend, or the scope of movement dependent upon a particular joint.

The Kraus-Weber variable presented two tasks. The first required the S, in a prone position, to raise his trunk from the floor for ten seconds while placing his hands behind his neck. The other Kraus-Weber task required the S, in a prone position, to raise his legs in the air for ten seconds. There was a great deal of similarity between these tasks and the leg raising task related to the Psychomotor Abilities Matrix.

The Angels-in-the-Snow tasks appeared to be limb-flexibility tasks like the kicking-height ability. One example of an Angels-in-the-Snow task has the S, in a prone position, separate his legs laterally, move them as far apart as possible, and then return his legs together. Another task has the S, while prone, move his left arm and right leg from a rest position, against the body, to one extended laterally from his body before finally returning the extremities to rest.

These two PPMS variables, Kraus-Weber and Angels-in-the-Snow, are related to the Psychomotor Abilities Matrix. However, they appeared to have little in common except the fact that they are both done in a prone position. This suggested the possibility that some abilities here may be differentiated on the basis of the spatial position of the body during the task. Indeed, this was the case when empirical Factor 8 was analyzed.

Empirical Factor 8, labelled limb and gross precision, was comprised of the PPMS sub-tests, Walking Board, Imitation of Movements, and Identification of Body Parts. The marginals which appeared to relate to the PPMS sub-tests were gross static balance and limb dynamic precision. Both of these designations were precision abilities, one static and one dynamic. Static precision has to do with the accuracy with which a bodily position can be held, while dynamic precision has to do with the precision of directed movements.

A task descriptive of a static precision ability is the two-foot rail-balance in which the S walks, heel-to-toe, on a one inch board. The PPMS walking board sub-test required the S to walk forwards, backwards, and sideways on a rail.

Dynamic precision is associated with tasks which do not appear to exemplify the related PPMS sub-test tasks. One such incongruent task was pursuit-aiming II in which the S traces through a series of small openings in a maze pattern. This lack of a suitable task description explaining the relationship between dynamic precision and the empirically associated PPMS variables probably resulted from the tests which Guilford used to postulate the psychomotor abilities. These abilities were derived from tests of physical fitness, apparatus-tests, and printed tests. Guilford used one kind of test in each analysis to determine his postulations.

However, the definition of dynamic precision was descriptive of the tasks related to the PPMS sub-tests which associated here. It will be recalled that dynamic precision had to do with

the precision of directed movements. The PPMS sub-test, Imitation of Movements, required the S to stand facing the examiner and to imitate precisely the arm movements made by the examiner in a manner analogous to semaphore signaling. Identification of Body Parts required the S to touch the specific body part named by the examiner.

Walking Board was a static precision task,while Imitation of Movements and Identification of Body Parts were dynamic precision tasks. Each of these PPMS variables appeared to be precision tasks performed in an erect body position. Thus, it seems possible that the tasks related to empirical Factors 6 and 8 are differentiated by the position the body assumed in performing the tasks associated with them.

It was evident that at least one variable related to empirical Factor 6, Angels-in-the-Snow, appeared to be an analog of the tasks seen in the sub-tests, Imitation of Movements and Identification of Body Parts. The latter sub-tests were associated with empirical Factor 8. These three PPMS sub-tests all involved directed movements of the limbs to certain fairly precise positions. This result supported the interpretation in this study of two empirical factors differentiated by the body position in which the related tasks were performed.

The final factor which emerged from this investigation was Factor 7 which was comprised of the PPMS sub-test variables, Jumping and Obstacle Course. This factor appeared to be related to the marginal designations, limb impulsion and gross coordina-

tion.

Impulsion pertains to the rate at which movements are initiated from the stationary position. An example of an impulsion task is a vertical jump. The tasks related to the Jumping variable involve unilateral and bilateral jumping, hopping, and skipping activities. They all appeared to be clearly associated with the limb impulsion designation.

The gross coordination ability is exemplified by the hurdle-jump and cable-jump tasks. In the latter, the S is required to jump through a cable that he holds. The Obstacle Course sub-test of the PPMS required the S to step over a knee-high barrier which was placed between two chairs, to duck under the barrier which has been moved to shoulder height, and to slip between a wall and the tip of a stick that has been positioned at a distance from the wall barely adequate to perform the activity. It appeared that the Obstacle Course variable was related here to the gross coordination ability.

Guilford (1958) noted in his discussion of the formulation of the Psychomotor matrix that, "This factor apparently involves coordinated activities of muscles of arms and legs, and perhaps also the trunk" (page 172). This statement was supported by the factorial association of the two PPMS sub-tests here, because both involved coordinated activities of the limbs and the trunk. However, these tests might be differentiated if their analysis included tasks which clearly separated the limb impulsion aspects of the PPMS variables from the gross coordination dimension.

To summarize, the hypothetical factor structure accurately predicted Factor 8. A total of nine factors emerged from the empirical analysis compared to 16 factors predicted from the logical analysis. Several reasons were offered to explain this discrepancy, one of which may have been the nature of the sub-tests employed in the present battery. These sub-tests may not have permitted an adequate differentiation of the abilities derived from Guilford's model. Another factor accounting for the discrepancy may be due to the nature of the subject population tested and/or the age of the population. Also, because these children did not come from a middle class environment, they may not have had the opportunity to acquire a highly differentiated ability structure. Finally, it is possible that Guilford's highly differentiated ability model is only appropriate at the adult level.

In general, the relationship of the sub-tests and the empirical factors that resulted from the data appeared to have a logical basis in the theoretical models proposed in Chapter I. It is suggested that analysis of the sub-test variables included in this study be performed with indices which are highly associated with the hypothetical factors. This should result in a more accurate prediction of the dimensional nature of some of those variables. This seems to be particularly true in the case of the visual and auditory sub-tests associated with the ITPA and the psychomotor tasks related to the PPMS.

However, it does not appear that re-analysis would affect either the suggested psycholinguistic process dichotomy of

reception and expression seen in the ITPA or the cognitive loading of some PPMS variables. The hypothetical interpretation of the DTVP as a unifactorial test would have resulted if less stress were placed on the inadequate test descriptions relative to their factor character, and greater stress were placed on the results from factorial research with the DTVP. The Wepman Auditory Discrimination Test appeared to be accurately predicted as a unidimensional test.

After the theoretical Factor structure and the empirical factor structure of this 28 sub-test battery have been compared, it is possible to suggest a set of sub-tests which assess each of the ability factors identified in this study.

In factor order, according to the empirical factor structure presented in Figure 4, these sub-tests are: (a) Visual Reception; (b) Verbal Expression; (c) Auditory Sequential Memory; (d) Spatial Relations; (e) the WADT; (f) Angels-in-the-Snow; (g) Jumping; (h) Identification of Body Parts; and (i) Chalkboard. In addition to being the nine sub-tests with the highest factor loadings, two of these tests accounted for a significant portion of the variance in the multiple regression analysis in which I.Q. was the criterion variable.

The addition of Auditory Reception and Grammatic Closure to this set of nine tests constitutes the major predictors of the nine ability factors and I.Q. A practical result of this investigation has been the identification of these 11 sub-tests which permits a reduction in diagnostic assessment time by at least 50%.

Limitations of This Study

The results and discussion of this investigation which have been presented are subject to certain limitations. These limitations are:

a. The possibility that kindergarten Ss would not possess sufficient maturity to differentiate the ability dimensions posited by Guilford's SI model;

b. The Ss used in this study were all disadvantaged children, whose characteristics are not representative of the general population of kindergarten Ss, making it difficult to generalize the factorial results to the latter population;

c. The further development of the factor analytic technique employed here may lead to a refinement of hypothesis confirmation as used in this study;

d. The interpretation of the dimensions, presented here, involved idiosyncratic decisions regarding the appropriateness of the variable associations and labelling;

e. The tasks represented by the Sub-tests, in the present battery of tests, may not have included tasks which differentiated the ability dimensions proposed by Guilford; and

f. The ability dimensions posited by Guilford may be appropriate only for adults or older school age Ss.

Implications for Future Research

Factor studies are usually exploratory. An investigator has reason to believe that a group of variables are related to a common underlying ability. Its identification will do a great deal to explicate the nature of the variable set he is interested in. The natural solution to his problem is the use of factor analysis. Once done the investigator should turn his attention to refining the variable set associated with the factor and verify the factor under a variety of circumstances. The impli-

cations for further research below apply the factor variable refinement and factor verification techniques.

This study identified nine factors presumed to be dimensions of learning disabilities. Using these dimensions as a model the following research appears fruitful:

1. A replication of this study using a sample of 300 Ss for the Four-Test Battery;

2. An item analysis of the data to determine which items are associated most highly to the factors. A pool of these items and related items generated by the investigator or selected from other tests could be administered and factor analyzed to select the items most highly associated with the factors. Presumably this refinement would make available a set of factor indices that have known factor association;

3. The sub-tests suggested as most representative of the factor structure should be subjected to analysis using marker variables to test the stability of this factor structure. Then additional related tests should be factor analyzed to determine the set of sub-tests most associated with this factor structure;

4. Additional tests presumed to be associated with learning disabilities should be placed into an analysis with the known factor variables and the factor character of the new tests determined. A model of dimensions of learning disabilities would result;

5. The factor scores of the Ss should be screened and samples selected from the lower third, middle third, and upper third of the Ss. These samples should be followed in school to determine the predictive effects of this factor structure on school learning. Presumably the lower third of this Ss pool will have significantly greater problems in learning;

6. Multiple regression equations should be generated and their efficiency tested. A limited indication of this battery's predictive power for I.Q. was the topic of one analysis. The need is to determine the best set of predictors for school achievement;

7. If these factors continue to show stability they could become the basis for research into remedial education. Presumably, if a child lacks ability in a factor, knowledge of the specific factor structure and character should permit one to suggest activities associated with those factors which would help improve the child's deficit;

8. This study suggested a possible deficit in the theoretical model underlying the ITPA. If the test is a three dimensional test, as suggested by this study, then the usefulness of the theoretical model is questioned. It should be examined to establish the validity of its constructs or the operational application of those constructs; and

9. The PPMS should be subjected to more rigorous analysis to establish if the cognitive/psycho-motor confusion in the sub-tests continues. If so, the test might be modified to place it appropriately as a perceptual motor test or a cognitive test.

## Summary

The major purpose of this study was to establish the underlying dimensions of a set of tests of learning disability. The tests chosed for study were the Illinois Test of Psycholinguistic Abilities, the Frostig Developmental Test of Visual Perception, the Wepman Auditory Discrimination Test, and the Purdue Perceptual Motor Survey.

It is assumed that the most economical application of theory results in the theoretical dimensions of a particular test matching the empirical dimensions found by factor analysis. The test is the operational model of the theory. If this is true, then a factor analysis of the present battery would result in 28 factors or dimensions.

It became apparent upon examination of the material in the tests that there was redundancy. To test the source of this

redundancy a suitable theoretical model was sought which would explain the dimensionality of this battery without repetition. The best theoretical models seemed to be Guilford's Structure of Intellect Model and his Matrix of Psychomotor Abilities. These two models provided the theoretical framework for positing a factor structure for this battery of 16 dimensions.

These hypotheses appeared to be the most economical explanation of the test battery and they summarized both the tasks associated with the tests and the existing research to form the hypothetical factor structure.

This test battery was administered to 305 disadvantaged kindergarten Ss. All the Ss took the ITPA, the DTVP, and the WADT but time limitations permitted the administration of the PPMS to only 93 Ss. All tests were given individually by examiners who were advanced students in Education or Psychology. The battery was given following the procedures of the test manuals. To standardize the WADT it was recorded on tape to avoid examiner differences in reading of the items. One sub-test of the PPMS, Rhythmic Writing, was modified to include only the first three items. The investigator felt these were the only items suitable for use with the Ss.

All the data analyses were done in the Michigan State University Computer Center using the CDC 3600 computer. The data were submitted to Principal Axis Factor Analysis with Varimax Rotation. The cut-off for determining the number of factors to be rotated was an eigenvalue of 1.000. All factors

that were interpreted had at least one variable loading on them in excess of .70, and the entire variable set associated with the factor was loaded at least .50.

In addition to these analyses, a Two-Way Analysis of Variance for age and sex was done with the factor scores. These are standardized scores which are derived from the raw scores multiplied by a weighted value associated with the factor loading. In effect, the factor score transforms the factor into a variable. The advantage of these scores is that they are useful for individual comparisons.

The final analyses were multiple regression routines to determine for this set of variables the best predictors of I.Q. The Least Squares Delete program begins with the full set of independent variables and deletes them one at a time until all variables which do not contribute significantly to the variance of the criterion are eliminated. The Least Squares Add program reverses the process by beginning with the best variable and adding variables until those variables which contribute significantly to the criterion variance are accounted for. The resulting variables are the best set to begin with in predicting I.Q.

Separate factor analyses for the Four Tests, for Three Tests (excluding the PPMS), for the PPMS, for the ITPA, and for the DTVP were consistent in their results. The major conclusions of this study were:

1. The Four-Test Battery was essentially one of at lease nine dimensions. These factors were Cognition

of Semantic Relations, Convergent Production of Semantic Relations, Memory for Symbolic Systems, Cognition of Figural Systems, Evaluation of Symbolic Units, Trunk-Limb Flexibility and Strength, Limb Impulsion and Gross Coordination, Limb and Gross Precision, and Memory for Figural Units;

2. The succeeding analyses each produced similar results. The factorial character of the separate tests in the battery is as follows:

   a. The ITPA includes at least three factors. These are Cognition of Semantic Relations, Convergent Production of Semantic Relations, and Memory for Symbolic Systems.

   b. The DTVP is a unidimensional test. This factor is described as Cognition of Figural Systems.

   c. The WADT is a unidimensional test involving the factor, Evaluation of Symbolic Units.

   d. The PPMS includes at least four dimensions and these include one clearly cognitive factor (Memory for Figural Units) and three psychomotor dimensions. These are Trunk-Limb Flexibility and Strength, Limb Impulsion and Gross Coordination, and Limb and Gross Precision.

3. The theory underlying the ITPA inadequately explains the dimensional character of the test. It was suggested that the model be thoroughly reviewed. From these results it appeared the dimensional character of the ITPA sub-tests are best explained by the reception/expression dichotomy;

4. It is suggested that nine sub-tests instead of 28 could be used to approximate the underlying nature of this

battery. These are Visual Reception (ITPA), Verbal Expression (ITPA), Auditory Sequential Memory (ITPA), Spatial Relations (DTVP), WADT, Angels-in-the-Snow (PPMS), Jumping (PPMS), Identification of Body Parts (PPMS), and Chalkboard (PPMS):

5. Auditory Association, Auditory Sequential Memory, Grammatic Closure, and Spatial Relations seem to be the best set of variables for predicting I.Q. from this battery.

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# APPENDIX

Appendix 1a

Means and Standard Deviations of All Variables[1] for Four Tests.

| Variables | | Means | Standard Deviation |
|---|---|---|---|
| 1 | AR | 18.882 | 5.586 |
| 2 | VR | 15.548 | 4.744 |
| 3 | VSM | 15.430 | 5.564 |
| 4 | AA | 16.839 | 4.838 |
| 5 | ASM | 22.183 | 7.885 |
| 6 | VA | 16.850 | 5.103 |
| 7 | VC | 21.301 | 6.589 |
| 8 | VE | 17.720 | 5.569 |
| 9 | GC | 11.333 | 3.754 |
| 10 | ME | 20.559 | 6.525 |
| 11 | EMC | 11.914 | 3.723 |
| 12 | FG | 11.473 | 3.923 |
| 13 | FC | 5.935 | 2.828 |
| 14 | PIS | 4.668 | 1.517 |
| 15 | SR | 3.011 | 1.787 |
| 16 | DIFF | 18.828 | 4.865 |
| 17 | SAME | 8.366 | 2.088 |
| 18 | WB | 10.398 | 1.532 |
| 19 | J | 3.151 | .961 |
| 20 | IBP | 3.054 | 1.158 |
| 21 | IM | 2.979 | .703 |
| 22 | OC | 3.742 | .566 |
| 23 | K-W | 3.656 | .596 |
| 24 | AIS | 3.441 | .740 |
| 25 | CB | 13.161 | 2.142 |
| 26 | RW | 9.441 | 2.425 |
| 27 | OP | 13.505 | 2.754 |
| 28 | VAF | 5.570 | 1.668 |

[1] N = 93

Appendix 1 b

Intercorrelation Matrix of All Variables for Four Tests[a]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. AR | --- | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. VR | .36 | --- | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. VSM | .25 | .15 | --- | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. AA | .48 | .27 | .38 | --- | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. ASM | .31 | .22 | .26 | .34 | --- | | | | | | | | | | | | | | | | | | | | | | | |
| 6. VA | .21 | .30 | .28 | .47 | .05 | --- | | | | | | | | | | | | | | | | | | | | | | |
| 7. VC | .23 | .32 | .11 | .23 | .12 | .23 | --- | | | | | | | | | | | | | | | | | | | | | |
| 8. VE | .23 | .18 | .27 | .30 | .00 | .19 | -.05 | --- | | | | | | | | | | | | | | | | | | | | |
| 9. GC | .39 | .29 | .18 | .53 | .26 | .34 | .09 | .27 | --- | | | | | | | | | | | | | | | | | | | |
| 10. ME | .14 | .09 | .24 | .25 | -.04 | .35 | .12 | .51 | .14 | --- | | | | | | | | | | | | | | | | | | |
| 11. EMC | -.02 | .05 | .01 | .19 | -.02 | .10 | .01 | -.04 | .16 | -.01 | --- | | | | | | | | | | | | | | | | | |
| 12. F-G | .09 | .21 | .17 | .15 | .17 | .15 | .21 | .10 | .08 | .18 | .18 | --- | | | | | | | | | | | | | | | | |
| 13. FC | .15 | .10 | .19 | .22 | .30 | .21 | .06 | -.13 | .30 | -.09 | .10 | .30 | --- | | | | | | | | | | | | | | | |
| 14. PIS | -.03 | .16 | .23 | .13 | .15 | .08 | .06 | .26 | .26 | .19 | .13 | .22 | .19 | --- | | | | | | | | | | | | | | |
| 15. SR | .07 | .08 | .07 | .26 | .15 | .34 | .12 | .15 | .24 | .21 | .36 | .43 | .30 | .35 | --- | | | | | | | | | | | | | |
| 16. DIFF | .10 | .10 | .07 | .21 | .27 | .13 | -.01 | .19 | .22 | -.23 | .14 | .01 | .18 | .00 | .13 | --- | | | | | | | | | | | | |
| 17. SAME | .25. | .11 | .24 | .36 | .22 | .13 | .14 | .17 | .31 | .18 | .14 | .19 | .19 | .09 | .10 | -.20 | --- | | | | | | | | | | | |
| 18. WB | .00 | .14 | .09 | .23 | .20 | .12 | .07 | .10 | .13 | .04 | -.01 | .12 | .25 | .12 | .14 | .00 | .21 | --- | | | | | | | | | | |
| 19. J | .05 | .11 | .10 | .02 | .37 | .06 | .06 | -.20 | .02 | -.09 | -.08 | .14 | .19 | .00 | .04 | .15 | .07 | .22 | --- | | | | | | | | | |
| 20. IBP | .05 | .06 | .04 | .17 | .12 | .13 | .06 | -.06 | .22 | -.09 | -.01 | .10 | .13 | -.03 | -.01 | .29 | .00 | -.05 | .30 | --- | | | | | | | | |
| 21. IM | .11 | .02 | .14 | .13 | .11 | .13 | .07 | .10 | .12 | -.02 | .19 | .23 | .07 | .04 | .23 | .16 | -.01 | .06 | .20 | .24 | --- | | | | | | | |
| 22. OC | -.07 | -.07 | .05 | -.07 | .07 | .01 | -.06 | .04 | .01 | -.10 | .07 | .09 | -.02 | .07 | .07 | -.08 | .03 | .16 | .21 | .17 | .20 | --- | | | | | | |
| 23. K-W | .04 | .19 | .10 | .22 | .11 | .20 | .21 | .06 | .12 | .09 | .07 | .29 | .09 | .10 | .20 | .12 | -.06 | .23 | .09 | .14 | .21 | .12 | --- | | | | | |
| 24. AIS | .04 | .10 | .09 | .29 | .19 | .12 | .23 | -.10 | .09 | .01 | .12 | .27 | .23 | .00 | .23 | .14 | .10 | .37 | .29 | .17 | .35 | .07 | .47 | --- | | | | |
| 25. CB | .02 | .11 | .22 | .26 | .15 | .23 | .18 | .14 | .24 | .25 | .13 | .40 | .22 | .14 | .35 | .02 | .25 | .35 | .14 | .33 | .24 | .02 | .32 | .40 | --- | | | |
| 26. RW | .07 | -.03 | .10 | .13 | .20 | .17 | .15 | .08 | .15 | .14 | .17 | .40 | .24 | .32 | .40 | .11 | .12 | .21 | .10 | .16 | .35 | .15 | .43 | .26 | .45 | --- | | |
| 27. OP | .05 | -.04 | .14 | .06 | .28 | -.08 | .11 | .04 | .08 | .12 | .17 | .27 | .21 | .01 | .25 | .00 | .31 | .25 | .21 | .08 | .17 | .17 | .14 | .18 | .36 | .36 | --- | |
| 28. VAF | .05 | -.05 | .13 | .14 | .15 | .04 | .20 | .07 | .16 | .02 | .03 | .30 | .21 | .16 | .25 | .24 | .01 | .20 | .33 | .37 | .27 | .22 | .15 | .15 | .36 | .30 | .27 | --- |

a. N=93

Appendix 1c

**Means and Standard Deviations of All Variables[1] for Three Tests**

| Variables | | Means | Standard Deviation |
|---|---|---|---|
| 1 | AR | 18.925 | 5.977 |
| 2 | VR | 14.931 | 5.142 |
| 3 | VSM | 14.823 | 5.279 |
| 4 | AA | 17.033 | 5.187 |
| 5 | ASM | 22.885 | 8.349 |
| 6 | VA | 16.492 | 5.006 |
| 7 | VC | 20.180 | 6.637 |
| 8 | VE | 17.764 | 5.776 |
| 9 | GC | 11.810 | 4.881 |
| 10 | ME | 21.193 | 5.710 |
| 11 | EMC | 11.456 | 4.046 |
| 12 | F-G | 11.738 | 4.630 |
| 13 | FC | 5.879 | 3.242 |
| 14 | PIS | 4.849 | 1.711 |
| 15 | SR | 2.885 | 1.897 |
| 16 | DIFF | 19.469 | 5.418 |
| 17 | SAME | 8.108 | 2.294 |

[1]N = 305

Appendix 1d

Intercorrelation Matrix of all Variables[1] for Three Tests

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AR | --- | | | | | | | | | | | | | | | | |
| 2 | VR | .34 | --- | | | | | | | | | | | | | | | |
| 3 | VSM | .33 | .23 | | | | | | | | | | | | | | | |
| 4 | AA | .47 | .36 | .38 | --- | | | | | | | | | | | | | |
| 5 | ASM | .25 | .17 | .28 | .32 | --- | | | | | | | | | | | | |
| 6 | VA | .31 | .40 | .27 | .46 | .17 | --- | | | | | | | | | | | |
| 7 | VC | .36 | .27 | .23 | .31 | .09 | .31 | --- | | | | | | | | | | |
| 8 | VE | .31 | .19 | .28 | .32 | .07 | .21 | .04 | --- | | | | | | | | | |
| 9 | GC | .42 | .29 | .32 | .61 | .26 | .37 | .30 | .29 | --- | | | | | | | | |
| 10 | ME | .17 | .14 | .22 | .24 | .06 | .24 | .12 | .52 | .25 | --- | | | | | | | |
| 11 | EMC | .16 | .15 | .18 | .26 | .02 | .22 | .30 | .12 | .28 | .12 | --- | | | | | | |
| 12 | F-G | .23 | .27 | .26 | .34 | .18 | .31 | .37 | .16 | .32 | .19 | .35 | --- | | | | | |
| 13 | FC | .17 | .12 | .17 | .22 | .10 | .19 | .20 | .04 | .32 | .06 | .14 | .35 | --- | | | | |
| 14 | PIS | .32 | .23 | .43 | .40 | .13 | .28 | .27 | .21 | .41 | .14 | .26 | .37 | .25 | --- | | | |
| 15 | SR | .29 | .26 | .35 | .48 | .21 | .40 | .33 | .16 | .44 | .19 | .36 | .58 | .31 | .52 | --- | | |
| 16 | DIFF | .20 | .12 | .18 | .24 | .29 | .18 | .07 | .06 | .19 | .01 | .13 | .15 | .12 | .16 | .21 | --- | |
| 17 | SAME | .21 | .19 | .25 | .30 | .15 | .19 | .15 | .12 | .30 | .08 | .17 | .24 | .14 | .22 | .29 | .21 | --- |

[1] N = 305

Appendix 1e

**Intercorrelation Matrix of Eleven Variables[1] for the PPMS**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WB | --- | | | | | | | | | | |
| 2 | J | .22 | --- | | | | | | | | | |
| 3 | IBP | .05 | .30 | --- | | | | | | | | |
| 4 | IM | .06 | .20 | .24 | --- | | | | | | | |
| 5 | OC | .16 | .21 | .17 | .20 | --- | | | | | | |
| 6 | KW | .23 | .09 | .14 | .21 | .12 | --- | | | | | |
| 7 | AIS | .37 | .29 | .17 | .35 | .07 | .47 | --- | | | | |
| 8 | CB | .35 | .14 | .33 | .24 | .02 | .23 | .40 | --- | | | |
| 9 | RW | .21 | .10 | .16 | .35 | .15 | .43 | .26 | .45 | --- | | |
| 10 | OP | .25 | .21 | .08 | .17 | .17 | .14 | .18 | .36 | .36 | --- | |
| 11 | VAF | .20 | .33 | .37 | .27 | .22 | .15 | .15 | .36 | .30 | .27 | --- |

[1]N = 93

Appendix 1f

Intercorrelation Matrix of Ten Variables[1] for the ITPA

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AR | --- | | | | | | | | | |
| 2 | VR | .34 | --- | | | | | | | | |
| 3 | VSM | .33 | .23 | --- | | | | | | | |
| 4 | AA | .47 | .36 | .38 | --- | | | | | | |
| 5 | ASM | .25 | .17 | .28 | .32 | --- | | | | | |
| 6 | VA | .31 | .40 | .27 | .46 | .17 | --- | | | | |
| 7 | VC | .36 | .27 | .23 | .31 | .09 | .31 | --- | | | |
| 8 | VE | .31 | .19 | .28 | .32 | .07 | .21 | .05 | --- | | |
| 9 | GC | .42 | .29 | .32 | .61 | .26 | .37 | .30 | .29 | --- | |
| 10 | ME | .17 | .14 | .22 | .24 | .06 | .24 | .12 | .52 | .25 | --- |

[1]N = 305

## Appendix 1g

Intercorrelation Matrix of Five Variables[1] for the DTVP

| | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | EMC | --- | | | | |
| 2 | FG | .35 | --- | | | |
| 3 | FC | .14 | .35 | --- | | |
| 4 | PIS | .26 | .37 | .25 | --- | |
| 5 | SR | .36 | .58 | .31 | .52 | --- |

[1]N = 305

Appendix 2a

Intercorrelations of Items of the Perceptual-Motor Survey [a]

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Walking Board: Forward | -- | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2. Walking Board: Backward | 53 | -- | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3. Walking Board: Sidewise | 43 | 44 | -- | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4. Jumping | 15 | 26 | 07 | -- | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5. Identification of Body Parts | 14 | 27 | 18 | 29 | -- | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6. Imitation of Movements | 15 | 27 | 15 | 37 | 29 | -- | | | | | | | | | | | | | | | | | | | | | | | | |
| 7. Obstacle Course | 20 | 18 | 19 | 03 | 14 | 08 | -- | | | | | | | | | | | | | | | | | | | | | | | |
| 8. Chalkboard Circle | 12 | 27 | 16 | 32 | 28 | 32 | 10 | -- | | | | | | | | | | | | | | | | | | | | | | |
| 9. Chalkboard: Double Circle | 13 | 34 | 24 | 23 | 25 | 20 | 08 | 48 | -- | | | | | | | | | | | | | | | | | | | | | |
| 10. Chalkboard: Lines, Lateral | 27 | 29 | 18 | 26 | 26 | 31 | 10 | 42 | 32 | -- | | | | | | | | | | | | | | | | | | | | |
| 11. Chalkboard: Lines, Vertical | 16 | 27 | 15 | 28 | 28 | 27 | 13 | 34 | 40 | 41 | -- | | | | | | | | | | | | | | | | | | | |
| 12. Kraus-Weber (items 4 and 5) | 19 | 16 | 11 | 16 | 12 | 03 | 08 | 15 | 09 | 22 | 19 | -- | | | | | | | | | | | | | | | | | | |
| 13. Angels-in-the-Snow | 18 | 20 | 24 | 24 | 24 | 29 | 16 | 21 | 28 | 25 | 24 | 14 | -- | | | | | | | | | | | | | | | | | |
| 14. Ocular Pursuits: Both Lateral | 15 | 13 | 06 | 21 | 26 | 39 | 16 | 09 | 11 | 22 | 17 | 17 | 27 | -- | | | | | | | | | | | | | | | | |
| 15. Ocular Pursuits: Both Vertical | 11 | 17 | 10 | 22 | 31 | 40 | 16 | 14 | 21 | 18 | 20 | 14 | 32 | 08 | -- | | | | | | | | | | | | | | | |
| 16. Ocular Pursuits: Both Diagonal | 16 | 13 | 08 | 15 | 23 | 34 | 11 | 11 | 12 | 21 | 17 | 21 | 23 | 75 | 76 | -- | | | | | | | | | | | | | | |
| 17. Ocular Pursuits: Both Rotary | 07 | 07 | 07 | 23 | 21 | 31 | 20 | 08 | 05 | 13 | 16 | 08 | 22 | 71 | 70 | 80 | -- | | | | | | | | | | | | | |
| 18. Ocular Pursuits: Both Lateral | 11 | 11 | 09 | 22 | 27 | 34 | 14 | 22 | 20 | 32 | 28 | 12 | 26 | 67 | 57 | 61 | 57 | -- | | | | | | | | | | | | |
| 19. Ocular Pursuits: Right Vertical | 10 | 12 | 09 | 14 | 24 | 24 | 12 | 17 | 20 | 26 | 20 | 12 | 20 | 63 | 66 | 62 | 57 | 79 | -- | | | | | | | | | | | |
| 20. Ocular Pursuits: Right Diagonal | 13 | 10 | 09 | 24 | 17 | 23 | 23 | 19 | 19 | 23 | 22 | 20 | 23 | 62 | 62 | 68 | 63 | 72 | 75 | -- | | | | | | | | | | |
| 21. Ocular Pursuits: Right Rotary | 08 | 07 | 08 | 25 | 19 | 29 | 27 | 13 | 11 | 19 | 22 | 10 | 24 | 61 | 54 | 61 | 64 | 73 | 70 | 79 | -- | | | | | | | | | |
| 22. Ocular Pursuits: Left Lateral | 14 | 18 | 11 | 21 | 30 | 32 | 19 | 16 | 13 | 26 | 20 | 22 | 30 | 72 | 66 | 68 | 65 | 68 | 64 | 60 | 56 | -- | | | | | | | | |
| 23. Ocular Pursuits: Left Vertical | 18 | 21 | 10 | 27 | 32 | 32 | 22 | 15 | 16 | 20 | 18 | 15 | 28 | 62 | 67 | 67 | 62 | 57 | 61 | 58 | 56 | 83 | -- | | | | | | | |
| 24. Ocular Pursuits: Left Diagonal | 11 | 12 | 24 | 20 | 27 | 15 | 18 | 13 | 19 | 10 | 13 | 30 | 16 | 57 | 59 | 64 | 62 | 54 | 61 | 68 | 64 | 71 | 74 | -- | | | | | | |
| 25. Ocular Pursuits: Left Rotary | 15 | 21 | 07 | 28 | 31 | 25 | 21 | 17 | 20 | 13 | 13 | 22 | 23 | 60 | 62 | 58 | 59 | 51 | 58 | 62 | 58 | 75 | 75 | 83 | -- | | | | | |
| 26. Developmental Drawing: Form | 19 | 11 | -02 | 11 | 12 | 11 | 06 | 10 | 20 | 17 | 19 | 08 | 11 | 22 | 13 | 20 | 14 | 15 | 19 | 21 | 24 | 19 | 18 | 19 | 20 | -- | | | | |
| 27. Developmental Drawing: Organization | 16 | 11 | 08 | 19 | 22 | 18 | 16 | 20 | 17 | 24 | 27 | 14 | 06 | 21 | 17 | 26 | 18 | 26 | 19 | 19 | 20 | 25 | 31 | 17 | 16 | 34 | -- | | | |
| 28. Rhythmic Writing: Rhythm | 28 | 30 | 18 | 28 | 23 | 21 | 15 | 29 | 20 | 31 | 25 | 31 | 19 | 20 | 21 | 20 | 20 | 21 | 21 | 30 | 16 | 32 | 32 | 25 | 32 | 08 | 25 | -- | | |
| 29. Rhythmic Writing: Reproduction | 24 | 37 | 24 | 44 | 32 | 33 | 12 | 38 | 37 | 35 | 29 | 17 | 27 | 22 | 25 | 20 | 21 | 27 | 21 | 25 | 18 | 31 | 33 | 24 | 30 | 16 | 42 | 58 | -- | |
| 30. Rhythmic Writing: Orientation | 28 | 22 | 29 | 14 | 16 | 11 | 17 | 29 | 25 | 35 | 26 | 24 | 10 | 15 | 17 | 17 | 16 | 14 | 19 | 24 | 15 | 28 | 29 | 24 | 26 | 15 | 29 | 55 | 54 | -- |

Appendix 2a

Note - A correlation of .14 is statistically different from zero at the .05 level; of .18, at the .01 level.

[a]Decimal point omitted.

[b]After Roach and Kephart, 1966. Pages 24 & 25.

Appendix 2b

VARIMAX ROTATED FACTOR MATRIX
Purdue Perceptual-Motor Survey

| Tasks | Factors | | | | | | |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | $h^2$ |
| 1. Walking Board, Forward | .03 | .04 | .77 | -.18 | .19 | .07 | .67 |
| 2. Walking Board, Backward | .01 | .21 | .68 | -.16 | -.01 | .33 | .64 |
| 3. Walking Board, Sideways | .03 | .17 | .74 | -.15 | -.18 | .03 | .63 |
| 4. Jumping | .13 | .21 | -.04 | -.18 | .07 | .65 | .53 |
| 5. Ident. of Body Parts | .20 | .17 | .14 | -.10 | .07 | .54 | .40 |
| 6. Imitation of Movements | .26 | .27 | .10 | .11 | .07 | .63 | .57 |
| 7. Obstacle Course | -.20 | .03 | .44 | -.07 | .14 | -.07 | .26 |
| 8. Chalkboard: Circle | .03 | .67 | .00 | -.25 | -.04 | .26 | .58 |
| 9. Chalkboard: DBL Circle | .06 | .66 | .15 | -.14 | -.01 | .18 | .51 |
| 10. Chalkboard: Lines, Lateral | .12 | .64 | .15 | -.21 | .16 | .11 | .53 |
| 11. Chalkboard: Lines, Vertical | .11 | .63 | .10 | -.11 | .21 | -.06 | .30 |
| 12. Kraus-Weber | -.15 | .09 | .12 | -.50 | .00 | -.06 | .30 |
| 13. Angels-in-the-Snow | -.23 | .29 | .28 | .07 | -.10 | .37 | .37 |
| 14. Ocular Pursuits, Both eyes, Lateral | .75 | .06 | .10 | .01 | .28 | .12 | .66 |
| 15. OP, Both eyes, Vertical | .73 | .10 | .06 | -.09 | -.16 | .30 | .66 |
| 16. OP, Both eyes, Diagonal | .83 | .02 | .08 | -.04 | .11 | .14 | .74 |
| 17. OP, Both eyes, Rotary | .82 | -.04 | .03 | -.02 | .06 | .19 | .71 |
| 18. Ocular Pursuits, Right eye, Lateral | .78 | .36 | .00 | .02 | .09 | .04 | .75 |
| 19. OP, Right eye, Vertical | .82 | .28 | .02 | -.04 | .03 | -.06 | .76 |
| 20. OP, Right eye, Diagonal | .83 | .24 | .04 | -.14 | .05 | -.08 | .78 |
| 21. OP, Right eye, Rotary | .81 | .21 | .05 | .04 | .14 | -.02 | .73 |
| 22. Ocular Pursuits, Left Eye, Lateral | .81 | .00 | .08 | -.23 | .07 | .22 | .77 |
| 23. OP, Left eye, Vertical | .77 | -.07 | .11 | -.25 | .09 | .30 | .77 |
| 24. OP, Left eye, Diagonal | .81 | -.05 | .12 | -.29 | -.04 | .05 | .75 |
| 25. OP, Left eye, Rotary | .76 | -.08 | .09 | -.29 | -.01 | .24 | .74 |
| 26. Developmental Drawing: Form | .16 | .11 | .10 | .01 | .75 | .03 | .62 |
| 27. Developmental Drawing: Organization | .13 | .12 | .01 | -.29 | .69 | .18 | .62 |
| 28. Rhythmic Writing: Rhythm | .15 | .15 | .11 | -.75 | .03 | .21 | .66 |
| 29. Rhythmic Writing: Reproduction | .11 | .27 | .10 | -.60 | .17 | .45 | .68 |
| 30. Rhythmic Writing: Orientation | .11 | .23 | .17 | -.75 | .12 | -.03 | .67 |
| $V_i$[1] | .26 | .08 | .07 | .08 | .05 | .07 | |

$V\ (\Sigma V_i) = .61$[2]

[1] $V_i$ = % of variance explained by factor

[2] $V\ (\Sigma V_i)$ = % of total variance explained by all factors