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ABSTRACT

The inter-subject/intra-subject subtest patterns (profiles) of the same sample of gifted children were examined based on factors found in a previous study of the Raven Coloured Progressive Matrices Test (CPM) that investigated structural properties with specific application to a sample of gifted children. The sample consisted of 166 children (78 females and 88 males) aged 37 months to 137 months who had been observed to be performing at accelerated levels of ability. An examination of the CPM subtests derived from the three factors identified in an earlier study confirms the impression that the CPM is an internally consistent measure that seems to assess one trait with three potentially related facets. The CPM appears to have three identifiable visual-spatial abilities, and children do show intra-individual variations in the subtest pattern, although in most cases the variation is not excessive. Findings with these gifted children are consistent with those for a sample of normal children. Ten tables present study data. (SLD)

Analysis of the Raven CPM Subtest Scores for a Sample of Gifted Children

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Cognition is a psychological construct consisting of many components which have been defined and then clustered into a variety of configurations by authors of different tests. Each test component represents a sample of cognitive behaviors and these cumulative samples may be regarded as the author's concept of the major components of intellect. Honeck, Case, and Firment (1991) have described cognitive psychology as, ". . . the study of perception, learning, memory, reasoning, problem solving, decision making, and the like." (p. xiv).

Cognitive test batteries have different configurations of these components of cognition. Among common tests of cognitive abilities are measures such as the WISC III, in which 13 subtests (with many items in each subtest) comprise an appraisal of intellect (Wechsler, 1991). The WAIS-R has 11 subtests (Wechsler, 1981) and the Stanford Binet 4th Edition has 4 major areas each of which is made up of 3 or 4 subareas and each of these subareas has many items (Thorndike, R.L., Hagen, E.P. & Sattler, J.M., 1986). On the Kaufman ABC Battery, which is composed of cognitive and achievement sections, the cognitive section has 10 subtests which represent the areas that the Kaufmans have assembled as representing cognition (Kaufman, A.S. & Kaufman, N.L., 1983).

These cognitive abilities are clustered into subtests which represent patterns of intellectual strengths and weaknesses for any individual. Variations in subtest patterns are regarded as educationally significant since they reflect intra-individual patterns of cognitive functioning which are important for understanding children's cognitive developmental patterns and achievement profiles. The relevance of subtest patterns has been discussed in test manuals accompanying each of the major cognitive measures mentioned above and in other interpretive literature. In discussing profile analysis as related to the WISC-R interpretation, Sattler (1988) has written that,

> "The goal of profile analysis is not to classify or categorize children; rather, it is to find clues about their abilities. Ideas generated from profile analysis must be viewed as hypotheses to be checked against other information about the examinee. By clarifying the functional nature of a child's learning problems, profile analysis may assist you in arriving at recommendations for clinical treatment, educational programs, or vocational placement." (p.166).

The analysis of profiles includes strategies for analyzing the extent of variation within it. Often, a statistical approach is used to analyze profile characteristics. Sattler commented that, "Profile analysis is dependent on the presence of statistically significant differences between scales, factor scores, or subtests that are compared." (p.167).

It is well known that profiles of individuals vary for a number of reasons. Children's cognitive development may exhibit unique patterns, affective and physical development varies, and differences in social, economic, and ethnic characteristics may influence profiles. Patterns of child rearing may also impact the characteristics of the profile.

Profiles are useful in studying intra-individual variation in responses to a standard set of tasks presented to the individual. Response patterns (profiles) are helpful in understanding children's development and for planning appropriate educational programs. Variation in patterns from child to child should be expected since that constitutes their individuality; their uniqueness and reflects their experiences. However, when profiles have unusual variations in patterns or in the size of subtest differences this may suggest a need for further study for a more in-depth understanding of a child's performance and/or behavior.

Kaufman (1976) analyzed the data of the 2200 subjects used in the standardization of the WISC-R and cautioned that,

". . . the normal child - just like the exceptional child, does not have a flat WISC-R profile, and will often evidence relative strengths and weaknesses when his test scores are subjected to empirical analysis." (p. 167).

But, Kaufman also indicated that, ". . . when a child has an unusual amount of scatter in his WISC-R profile, there may be diagnostic and remedial implications." (p. 167).

Although there is support for profile analysis as an analytical technique, there have been concerns about its use in individual cases. Criticism has centered about the potential unreliability of measures of short samples of behavior and brief task performance. Using a statistical perspective, critics have indicated that large standard errors are reasons to use extreme caution in subtest analysis, and there are some critics who would advocate abandonment of subtest analysis as a procedure altogether (Kaufman, 1979).

Subtest analysis has a long history of use and is a common practice in test interpretation. It can provide useful information in understanding children but must be used within the context of what we know about human development, learning, and the child's environmental circumstances. Subtest analysis, used cautiously, can lead to useful applications in preparing individualized learning plans and in child management endeavors.

Green and Kluever (1991) analyzed the structural properties of the Raven Coloured Progressive Matrices Test (Raven, 1962) in gifted children and concluded that the CPM added another useful dimension of cognition beyond that provided by other commonly used instruments when used for identification of gifted children. Furthermore, it was found to be "psychometrically sound with regard to reliability and internal structure" when used with gifted children (p.64). Three factors were identified; visual closure and pattern completion, visual analogies, and perceptual matching. They resemble the 3 areas of the CPM discussed in the Raven test manual (Raven, 1986) under the section on validity which suggests that validity characteristics of the CPM for the gifted children in this study are similar to those for the Raven standardization sample. The emphasis of the Green and Kluever study was on the structural properties of the CPM with specific application to a sample of gifted children. The purpose of this study was to examine the inter-subject / intra-subject subtest patterns (profiles) of the same sample of gifted children based on the factors found in the previous study. CPM subtest patterns within subjects and across subjects for children with extreme scores were of special interest as well as patterns reflecting age, gender, and Binet-LM IQ variations. Suggestions for educational programming applications are listed.

Method

The sample for this study consisted of 166 children who were observed by their preschool teachers and parents to be performing at accelerated levels of ability for their age. They were referred to the University Assessment Center for further study by their parents upon the recommendation of their teachers and/or pediatrician. There were 78 females and 88 males in the study ranging in age from 37 months to 137 months but with most children at the younger end of the age continuum. Males were slightly older than females (see Table 1). Children's Stanford-Binet IQ's ranged from 120 to above 164. The mean Binet IQ was 139 with nearly indentical mean IQ's for females (IQ = 140) and males (IQ = 138). Table 1 provides a description of this sample.

Place Table 1 here.

Raven CPM items were grouped into 3 subtests as identified in a previous study (Green & Kluever, 1991). The most interpretable factor analysis of those data was a 3 factor solution using a varimax rotation with loadings of .35 or higher used to determine item fit with factors. Each of these 3 factors was considered to be a subtest of the CPM for purposes of this study. The 11 items that loaded on more than one factor at >.35 were categorized as belonging to the factor on which they had the highest loading. These 3 factors, using a corrected solution (Jensen, 1990), accounted for 51 percent of the variance. The items and their corrected factor loadings that were attributed to each of the 3 subtests are listed in Table 2 below. Factor 1 was interpreted to require completion of visual analogies, factor 2 involves visual closure and pattern completion abilities, and factor 3 was a perceptual matching task.

Place Table 2 here.

Each subject's score on each subtest was defined as the number of correct items. Males tended to have higher mean scores on each subtest than females but they were also slightly older than females. Each subtest had a different number of items which accounts for some the difference in mean score from one subtest to another. Table 3 below is a description of these subtest means and differences in female/male scores.

Place Table 3 here.

Although there were essentially no gender differences among subtest scores, the scores for each subtest did increase with age. These increases are described in Table 4 where it will be noted that large increases in raw scores are associated with subtests 1 and 2 but much smaller increases with subtest 3. Perceptual matching as a task is one on which children achieve early success and demonstrate continuing development throughout the age scale range tested. But, children demonstrate relatively less early success on the visual closure/pattern matching and the visual analogies problems. However, they show continuing growth in this skill as they mature from 3 years to 10 years of age where nearly all of the designs are correctly identified. Table 4 which follows is description of this pattern of progression in scores with increasing age for each of the subtests.

Place Table 4 here.

The correlations among the CPM subtests were moderately high (.53 to .61). Certain other variables were correlated with each subtest score to explore these relationships. Age was found to be moderately correlated with each subtest but the Binet IQ showed no relationship to subtest scores. Table 5 lists these correlations and Table 6 which follows shows that the correlation patterns for males and females are nearly indentical to each other and to the pattern for the total group.

Place Table 5 here.

Place Table 6 here.

The moderately high correlation of children's age with each subtest suggested that it contributed significantly to the change in subtest score. Therefore, partial correlations were calculated to provide an indication of the relationship of subtests to each other controlling for the effect of age. These partial correlations were much lower than the original values. The correlation of subtest 1 with 2 decreased from .53 to .17. The subtest 2 correlation with subtest 3 decreased from .61 to .40 and the correlation of subtest 3 with subtest 2 decreased from .53 to .21. These partial correlation values suggest that the three subtests are relatively independent of each other and probably represent unique visual-spatial abilities.

Place Table 7 about here.

Place Table 8 about here.

A further concern in this study was the pattern of performance of children at the extremes of the 3 subtest scales. From Table 3 it was reported that the range of scores for subtest 1 was from 1 to 14, for subtest 2 it was from 1 to 9, and for subtest 3 it was from 1 to 11. Significant variation within subtest patterns is defined as a statistical procedure within many test manuals. For purposes of this study, subtest scores that were one or more standard deviations above or below the mean for the subtest were regarded as showing significant variation.

A pattern of age differences became apparent in analyzing the scores for children at the highest and lowest ranges of subtest scores. On subtest 1, the mean age for children having 1 or 2 items correct was 58.2 months but children who had 12 to 14 items correct had a mean age of 138 months. On subtest 2, a similar pattern was observed. Children with 3 or fewer items correct had a mean age of 51.7 months but children with 8 or 9 items correct had a mean age of 92.6 months. And, on subtest 3, children with 4 or fewer items correct had a mean age of 57.5 months while children with 10 or more items correct had a mean age of 95 months.

When the combination of scores on all 3 subtests was combined for children, the mean age for children with the highest scores on all 3 subtests was 109 months while the mean age for children with the lowest scores on all 3 subtests was 48 months. The within subject variation of high and low subtest scores as used in this study was extremely minimal. That is, no child was identified who had a very high score on one or two subtests and very low scores on the other one or two subtests. Tables 9 and 10 below display these performance patterns.

When Binet-LM IQ's of children with scores at the extremes of the Raven subtest profile were viewed, no pattern of Binet IQ could be associated with high or low Raven scores on any of the three subtests. The range of Binet IQ's and the means were nearly the same for children in both the high and low Raven score groupings for all three subtests. Evidence from this study suggests that visual spatial tasks of the Raven subtests are different from the tasks on the verbally oriented Binet scale.

Place Table 9 about here.

Place Table 10 about here.

Discussion

An examination of the subtests of the Raven CPM test derived from the 3 factors of the test identified in an earlier study confirmed the impression that the CPM is "an internally consistent measure that seems to assess one trait with 3 potential, related facets" (Green & Kluever, 1991, p. 63). The raw scores for each subtest showed a consistent increase with age. Very few inconsistencies were found where children's uneven growth is reflected in intra-individual subtest patterns. That is, children with high scores nearly always had 3 high scores and children with low scores typically had 3 low scores. Combinations of low and high scores within the same individual were rare.

In this sample of gifted children, the ages clustered near the younger end of the continuum. But, their patterns of success on the Raven subtests indicate that far more children had significantly high Raven subtest scores than significantly low scores. This is indicated in Tables 9 and 10 and is expected for this sample of gifted children. With more difficult items on the test, there may have been a more balanced distribution of significantly high and significantly low score profiles. This is an area for further development.

Age was found to correlate moderately with each of the 3 subtests and the subtests themselves were moderately correlated. Since age appeared to be highly related to increases in scores, a partial correlation was used to analyze the relationship between subtests controlling for the effect of age. These partial correlations resulted in significantly lower correlation values between the subtests. The three subtests seem to represent 3 independent visual spatial abilities.

The very low, almost negligible correlations with the Binet LM IQ's suggests again that neither the CPM test nor any of the subtests are related to this more verbally oriented scale. The CPM and subtests seem to provide additional and complementary information about childrens' cognition to that provided by the Binet scale. The combination of verbal cognition along with visual spatial processing ability is useful in understanding a child's pattern of approach to learning.

Among the subtests, children had the highest mean score on the perceptual matching task (M = 7.8) and the lowest mean score on the analogies task (M = 5.5). Although there were variations in the number of items on each subtest (analogies had the greatest number of items), there is a suggestion of differences in the age when children acquire sufficient maturity to achieve success on different types of cognitive tasks. If the subtests are regarded as independent cognitive visual spatial processing tasks, then it appears that some tasks represent earlier emerging abilities which mature quickly with scores reaching the ceiling of the test (perceptual matching tasks) and some tasks are later emerging abilities (visual closure, pattern matchings) which stretch upward but not reaching the ceiling level as readily as on the perceptual matching task. The perceptual matching task resembles a concrete operational stage of development whereas the analogies and pattern matching tasks seem to represent a more abstract cognitive processing task. Within the framework of Guilford's model of the Structure of the Intellect (Guilford, 1967), the perceptual matching tasks seem to represent Figural Units and Classes whereas the analogies and visual closure - pattern matching tasks resemble Figural Relations, Systems, Transformations, and Implications tasks. These are different Products within the SOI model and suggest again that the three Raven subtests are unique cognitive abilities requiring different visual spatial processing skill. They are SOI Figural abilities but different Products of Figural abilities.

Implications from this study suggest that the CPM has three identifiable visual-spatial abilities and that children do show intra-individual variation of subtest pattern but in most cases the variation is not excessive. Although this sample consists of a group of gifted children, the finding is consistent with the observations of Kaufman cited above concerning the variation of WISC-R subtest patterns for a sample of normal children. Unusual subtest patterns should be investigated further though.

These findings may be significant in understanding childrens' progress in early reading readiness, spelling, arithmetic, and handwriting tasks which may be delayed or accelerated abilities. A task analysis of the cognitive requirements of these curricular tasks can provide further insight into this problem. These findings have a potentially significant implication for understanding gifted children with some types of learning disabilities and/or other delays.

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Table 1

Description of the Sample[a]

Variable	Total Group Mean	SD	Range	Females Mean	SD	Range	Males Mean	SD	Range
Age (mo.)	69.3	22.0	37-137	67.4	23.2	37-137	71.0	21.4	40-132
Binet IQ	139	12.8	120-164	140	12.3	121-164	138	13.2	120-164

a (N = 166).

Table 2

Raven CPM Items and Factor Loadings Attributed to Each Subtest

Subtest 1		Subtest 2		Subtest 3	
B11	.82	B3	.64	AB6	.53
B12	.97	AB1	.89	AB12	.40
B10	.58	B2	.75	AB10	.51
B9	.73	AB3	.63	A8	.45
AB8	.68	A9	.57	A10	.50
B8	.61	AB5	.58	B4	.41
A11	.60	A1	.68	AB2	.36
A12	.66	AB11	.45	A5	.87
B6	.52	A3	.55	A4	.58
AB4	.57			A2	.92
AB9	.53				
A7	.41				
B7	.38				
AB7	.60				

Table 3

Means and Standard Deviations of Raven Subtest Scores by Total Group and by Gender

Subtest	No. of Items	Total Group Mean	SD	Range	Female Mean	SD	Male Mean	SD
Subtest 1	14 (39%)	5.5	3.4	1-14	5.3	3.5	5.8	3.4
Subtest 2	9 (25%)	6.8	1.9	1-9	6.5	1.9	7.0	1.9
Subtest 3	10 (28%)	7.8	1.9	1-11	7.7	1.9	7.9	1.9

Table 4

Means and Standard Deviations of Raven Subtests by Age Groups

Age Groups (months)	Subtest 1 Mean	SD	Subtest 2 Mean	SD	Subtest 3 Mean	SD
37 - 47 mo.	4.2	1.7	4.8	2.0	7.1	1.2
48 - 59 mo.	3.4	1.5	5.9	1.5	6.8	1.8
60 - 71 mo.	4.8	1.5	6.8	2.0	7.6	1.7
72 - 83 mo.	5.7	2.9	7.8	1.1	8.5	1.5
84 - 95 mo.	6.7	2.9	7.9	0.4	8.5	1.6
96 - 107 mo.	10.5	3.0	8.0	1.3	9.7	1.2
108 - 119 mo.	11.8	0.8	8.5	0.7	10.3	0.8
above 119 mo.	11.7	1.9	9.0	0	10.7	0.5

Table 5

Correlations of Raven Subtests and Related Variables (Total Group)

Variable	Subtest 2	Subtest 3	Age	Binet IQ
Subtest 1	.53	.61	.73	-.003
Subtest 2		.53	.59	.009
Subtest 3			.60	.004
Age				-.213

Table 6

Correlations of Raven Subtests, Age, Binet IQ (Females above and Males below the diagonal)

Variable	Subtest 1	Subtest 2	Subtest 3	Age	Binet IQ
Subtest 1	1.0	.53	.61	.73	-.003
Subtest 2	.53	1.00	.53	.59	.009
Subtest 3	.59	.56	1.00	.60	.004
Age	.74	.56	.61	1.00	-.21
Binet IQ	.05	.13	-.02	-.07	1.00

Table 7

Partial Correlations of CPM Subtests and Binet IQ Controlling for Age

Variable	Subtest 2	Subtest 3	Binet IQ
Subtest 1	.17	.40	.24
Subtest 2		.21	.13
Subtest 3			.16

Table 8

Partial Correlations of Raven Subtests Gender Controlling for Age (Females above, Males below the diagonal)

Variable	Subtest 1	Subtest 2	Subtest 3
Subtest 1	1.0	.10	.46
Subtest 2	.24	1.00	.51
Subtest 3	.33	.28	1.00

Table 9

Mean Ages of Students who Scored at the Upper and Lower End of the Range of Raven Raw Scores For Each Subtest

	Upper End of the Range	Lower End of the Range
Subtest 1	12-14 items correct	1-2 items correct
	N = 34	N = 26
	Age Range 64-137 mo.	Age Range 40-84 mo.
	M = 138 mo.	M = 58.2 mo.
	SD = 26.0	SD = 10.2
	IQ Range 121- >164	IQ Range 121- >164
	M = 138	M = 139
	SD = 13.5	SD = 15.3
Subtest 2	9 items correct	1-3 items correct
	N = 36	N = 21
	Age Range 58-137 mo.	Age Range 42-66 mo.
	M = 92.6 mo.	M = 51.7 mo.
	SD = 23.9	SD = 7.2
	IQ Range 122- >164	IQ Range 120- >164
	M = 141	M = 139
	SD = 12.8	SD = 13.8
Subtest 3	10-11 items correct	1-4 items correct
	N = 35	N = 22
	Age Range 58-137 mo.	Age Range 42-92 mo.
	M = 95	M = 57.5
	SD = 24.9	SD = 12.0
	IQ Range 121- >164	IQ = Range 122-159
	M = 140	M = 140
	SD = 13.2	SD = 12.6

Table 10

Mean Ages of Students for Combinations of Subtests 1, 2, and 3 at the Extreme Ends of the Continuum of CPM Raw Scores

Combination of 3 Subtests Subtest 1 (1-2 items correct) and Subtest 2 (1-4 items correct) and Subtest 3 (1-5 items correct)	N = 1 Age = 48 mo. Binet IQ = 138
Subtest 1 (9 or more items correct) and Subtest 2 (9 or more items correct) and Subtest 3 (10 or more items correct)	N = 17 Age - Range 76-137 mo. Mean 109 mo. S.D. 19.9 mo. IQ - Range 122-168 mo. Mean 142 mo. S.D. 14.9 mo.