A Cross-Validation Study of Patterns of Cognitive Ability in Children with Learning Difficulties, as Described by Factorially Defined WISC-R Verbal and Performance IQs

E.G. Nichols, James Inglis, J.S. Lawson, and Iain MacKay

WISC-R Verbal and Performance factorial IQs have been developed that can provide a formal statistical metric for the description of the patterns of cognitive ability exhibited by children with learning disability. The present study of 813 children includes test-retest data from 224 boys and girls. The results in large part confirm previous findings. These children suffer a progressive deterioration in verbal ability, whereas their nonverbal ability shows an increase in the earlier years, leveling off thereafter. These results can be used to evaluate the alternative hypothesis of developmental lag as opposed to deficit as a cause of learning disability.

Lawson and Inglis (1985) have argued that the pattern of intelligence test results shown by children with learning disability (LD) on the Wechsler (1949, 1974) tests may be most economically described in terms of the second bipolar, verbal-nonverbal factor derived from an unrotated principal components analysis of the Wechsler Intelligence Scale for Children-Revised (WISC-R) (Wechsler, 1974) normative data (Lawson & Inglis, 1984). This characteristic pattern can be summarized in terms of a Learning Disability Index (LDI). In order to calculate the LDI, the Factor 2 score coefficients are used in combination with the individual's subtest scaled scores; the method for its computation and its psychometric properties have been described in detail by Lawson and Inglis (1984). The LDI has a normal distribution with a mean of zero and standard deviation of 301 in the WISC-R standardization population, when 11 of the subtests (i.e., excluding Mazes) are considered. Lawson and Inglis (1985) have reviewed WISC (Wechsler, 1949), and WISC-R (Wechsler, 1974) data from a number of studies of children with LD and have demonstrated that the amount of deficit that these children show on any particular subtest is proportional to its verbal content thus defined. Children with LD therefore tend to return abnormally high positive LDI s as a result of the pattern of their WISC-R subtest scores.

Evidence for the validity of the LDI is now available from a number of sources. Tittemore, Lawson, and Inglis (1985) examined the WISC-R scores of 1,050 children categorized as LD who had been referred to a Canadian school board psychology service because of educational difficulties. These children returned mean scores on this index that were reliably higher than the expected scores of the normative population. As had been anticipated, this difference revealed a verbal deficit in their WISC-R test performance.

A study by Bellemare, Inglis, and Lawson (1986) compared the WISC-R test results of 24 boys with LD with the scores of the boys in the WISC-R standardization sample. The results of this study again showed that the boys with LD returned reliably higher LDI scores than did the nondisabled boys.

Inglis and Lawson (1985) have found, in a re-analysis of WISC-R data from Mexican-American and Papago children with LD collected by Mishra (1984a, 1984b), that the LDI also has good cross-cultural validity. They have, in addition, demonstrated (Inglis & Lawson, in press) that this index revealed an abnormal pattern in Wechsler data from 9,372 children with LD collated by Kavale and Forness (1984). The data had failed to yield evidence for the validity of the Bannatyne (1968) recategorization scores, the ACID grouping (i.e., depressed scores on Arithmetic, Coding, Information, and Digit Span; Swartz, 1974), or, indeed any other kind of pattern or cluster. Inglis and Lawson (1986) have also demonstrated that the same factorial model is applicable to the patterning of abilities shown by children with LD on other intelligence test batteries, such as the Kaufman Assessment Battery for Children (K-ABC) (Kaufman & Kaufman, 1983), a finding that has been extended to the British Ability Scales by Elliott and Tyler (in press).

Lawson, Inglis, and Tittemore (1987) have, however, acknowledged that in the use of the LDI there is a lack of a precise operational definition of the verbal and nonverbal components of intelligence, the imbalance of which produces abnormal LDI s. These investigators have, consequently, developed separate measures of verbal and nonverbal abilities based on a 45° rotation of the first and second principal components obtained from the analysis of the intercorrelations of the WISC-R subtests.

The factor weights have been so adjusted that when the sum of the multiples of the weights and the scaled scores are added to an appropriate constant, the resulting factor score has a mean of 100 and a standard deviation of 15 in the normative population. In other words, the factor scores have been expressed in Wechsler IQ equivalent form. These adjusted weights, together with the appropriate constants, are shown in Table 1. It can be seen that the minor weights on each factor (i.e., the more Performance-related subtests on the Verbal factor, and the more Verbal-related subtests on the Performance factor) are negative. Lawson et al. (1987) have argued that none of the subtests of the WISC-R reflect either pure verbal or pure nonverbal ability; all are factorially complex, some sampling more verbal ability, others more nonverbal ability. The negatively weighted subtests in each factor act as suppressor variables,
TABLE 1
WISC-R Mean Scaled Scores Together with Verbal and Performance Factorial IQs for Normative Children and Children with Learning Difficulties

<table>
<thead>
<tr>
<th>Subtests</th>
<th>Verbal Weights</th>
<th>Performance Weights</th>
<th>Normative children (N = 2,199)</th>
<th>Children with LD (N = 813)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boys (N = 1,099)</td>
<td>Girls (N = 1,100)</td>
</tr>
<tr>
<td>1. Information</td>
<td>1.05</td>
<td>0.03</td>
<td>10.59</td>
<td>9.55</td>
</tr>
<tr>
<td>2. Similarities</td>
<td>0.71</td>
<td>0.36</td>
<td>10.01</td>
<td>9.89</td>
</tr>
<tr>
<td>3. Arithmetic</td>
<td>1.63</td>
<td>−0.69</td>
<td>10.21</td>
<td>10.03</td>
</tr>
<tr>
<td>4. Vocabulary</td>
<td>1.08</td>
<td>0.03</td>
<td>10.22</td>
<td>9.88</td>
</tr>
<tr>
<td>5. Comprehension</td>
<td>0.65</td>
<td>0.35</td>
<td>10.19</td>
<td>9.92</td>
</tr>
<tr>
<td>6. Digit Span</td>
<td>2.02</td>
<td>−1.32</td>
<td>9.84</td>
<td>10.06</td>
</tr>
<tr>
<td>7. Picture Completion</td>
<td>−0.86</td>
<td>1.75</td>
<td>10.38</td>
<td>9.83</td>
</tr>
<tr>
<td>8. Picture Arrangement</td>
<td>−0.52</td>
<td>1.37</td>
<td>10.20</td>
<td>9.88</td>
</tr>
<tr>
<td>9. Block Design</td>
<td>−0.41</td>
<td>1.43</td>
<td>10.27</td>
<td>9.76</td>
</tr>
<tr>
<td>10. Object Assembly</td>
<td>−1.14</td>
<td>2.02</td>
<td>10.35</td>
<td>9.70</td>
</tr>
<tr>
<td>11. Coding</td>
<td>1.20</td>
<td>−0.56</td>
<td>9.24</td>
<td>10.80</td>
</tr>
<tr>
<td>Constant</td>
<td>45.94</td>
<td>52.30</td>
<td>99.19</td>
<td>101.09</td>
</tr>
<tr>
<td>VFIQ</td>
<td></td>
<td></td>
<td>102.64</td>
<td>97.96</td>
</tr>
</tbody>
</table>

ridding the Verbal factor of unwanted Performance factor variance, and removing Verbal factor variance from the Performance factor. These subtests are able to act as suppressor variables because their factor loadings (i.e., correlations) with the relevant factor are low, whereas their loadings on the other factor are high. Subtracting them to compute the factor score removes irrelevant variance without greatly affecting the valid variance on that factor. This yields relatively pure measures of verbal and nonverbal ability, respectively. Calculations of the mean Verbal factorial IQs (VFIQs) and Performance factorial IQs (PFIQs) for the boys and girls in the normative population revealed a reliable VFIQ advantage for the girls of about 2 IQ points, whereas the boys scored about 4 or 5 points higher than the girls in PFIQ.

Lawson et al. (1987) have gone on to show that these factorial measures produce a different pattern of results in children with LD. They found, in a cross-sectional study that involved different groups of children with LD at each age level from 6 to 16 years, that the mean VFIQ of these children was reliably lower than it was for nondisabled children, and that there was no difference between the boys and girls in the groups with LD. Furthermore, in these children the VFIQ actually declined with age between the years of 6 and 16. Their PFIQ scores, on the other hand, were reliably lower than those for the normal children at ages 6 and 7, but then rose to and remained at a normal level after age 8. Boys with LD returned reliably higher PFIQs than girls with LD.

A longitudinal study was also reported by Lawson et al. (1987) in which 47 such children (35 boys; 12 girls) were tested and then retested on the WISC-R after an interval of about 2 years. The results of these repeated measures served to confirm the findings of the cross-sectional study.

The present study was undertaken so as to examine further the validity and usefulness of the factorial IQ model, using another large sample of children diagnosed as LD, to see if these original findings could be cross-validated. This study was designed in two parts. First, another cross-sectional study of different age groups (N = 813) was undertaken so as to examine the age-related behavior of the VFIQ and the PFIQ in boys and girls with LD. Second, a longitudinal study was carried out using the WISC-R scores of a large subgroup of these children (N = 224) who had been tested and then retested on the WISC-R over a span of about 3 years. If the results of these two components of this study should also prove to be compatible, then this would provide strong confirmation that the trends found over different age groups do indeed reflect changes in individual children, rather than being the result of extraneous and uncontrolled variables.

It was therefore expected that:

1. (a) The VFIQs of these children would be lower than those of normative children and would, furthermore, decline with age.
   (b) The PFIQs of these children would initially be lower than those of the normative children, but would then increase with age to at least a normal level.
   (c) There would be no sex differences in the VFIQs, but there would be a difference in mean PFIQs in favor of the boys.

2. Similar patterns of results would be found in the VFIQ and PFIQ scores of children with LD who had been tested in their early school years, and then retested some time later.

METHOD

The records for the subjects of this study were obtained from the Lakeshore School Board in the Province of Que-
bec. This Board serves the predominantly English-speaking school system of western Montreal, which has about 13,000 students in 21 elementary and 5 secondary schools. Most of these children come from middle or upper middle class backgrounds. Extensive facilities are provided by the Division of Student Services for those children who are unable to cope adequately with the regular academic programs. Evaluation and remediation procedures are carried out by a full range of educational specialists (psychologists, psychometrists, social workers, speech and occupational therapists, and teachers of special education), and a variety of special class placements are available for students who experience difficulties in the regular classroom. Coordination of this service is managed from the Division's offices in the school board headquarters, which houses detailed files for students in the system. The great majority of children referred to Student Services are seen because they have problems with reading and writing. Their teachers may also have found them to be occasionally disruptive of the classroom scene. The diagnosis of "learning difficulty" is the category most frequently encountered in these records.

The Ministry of Education of the Province of Quebec (1983, p. 229) states, a consequence many files contain the results of repeated testing.

For the purpose of this study files were searched for the records of children categorized as LD, who had been tested on the WISC-R, and who had returned a Full Scale IQ of at least 80. Eight hundred and thirteen records of children (537 boys, 276 girls) ranging in age from 6 to 11 were drawn in this fashion so as to obtain the cross-sectional age data. Of these, 224 (161 boys, 63 girls) had been first tested at about 6 or 7 years of age, and then retested about 3 years later, so that their results could be used for the longitudinal part of this study.

RESULTS

1. Cross-sectional Data. The mean VFIQs and PFIQs for these children, subdivided by age and sex, are shown in Figure 1.

![Figure 1. Verbal and Performance Factorial IQ scores from the WISC-R for boys ($N=537$) and girls ($N=276$) with learning difficulties, between the ages of 6 and 11.](image-url)

Comparison of the mean IQ for all of the 813 children ($\bar{X} = 93.44, SD = 12.75$), with the mean VFIQ calculated by Lawson et al. (1987) for the WISC-R normative population ($\bar{X} = 100.14, SD = 15.05$), shows a reliable difference ($z = 12.69, p < .001$) between these groups in the predicted direction. The mean VFIQ for the boys is 93.24 ($SD = 12.71$); for the girls it is 93.81 ($SD = 12.81$). This difference is not reliable, $F(1,801) = 0.46, n.s.$ There is, however, a statistically significant effect of age on VFIQ in these children, $F(5,801) = 2.80, p < .02$, but no reliable Sex x Age interaction, $F(5,801) = 0.47, n.s.$

Comparison of the overall mean PFIQ of these children ($\bar{X} = 107.68, SD = 12.69$) with the mean PFIQ of the normative population ($\bar{X} = 100.30, SD = 15.28$) reveals a reliable difference between these groups ($z = 13.77, p < .001$) in favor of the children with LD. The mean PFIQ for the boys is 109.12.


2. Longitudinal Data. In the case of the children who were studied longitudin- 
ally, the boys were first tested at a mean age of 7.37 years (SD = 0.80), 
and then retested at 10.52 years (SD = 1.43). The mean age of the girls on 
the first occasion of testing was 7.88 years (SD = 1.31), and on the second oc- 
casion of testing it was 11.03 years (SD = 1.75). Their test-retest results are 
described in Table 2. The difference between the mean test and retest scores 
in the case of VFIQ and PFIQ have been evaluated for the boys and girls separ- 
ately, as well as for the total group, with the results indicated in the two columns 
headed Test vs. Retest. The difference between the boys and the girls on the 
separate occasions of testing have also been examined; the results of the relevant 
t tests are shown in the bottom row of Table 1.

In the case of the VFIQ, there is again a reliable decline between test and retest 
for both sexes, but there is no reliable difference between the boys and girls at 
either test or retest. Comparison of their mean VFIQs at test and retest with the 
mean VFIQs of normative boys (X̄ = 99.19, SD = 15.75) and normative girls 
(X̄ = 101.09, SD = 14.27), respectively, revealed that these mean scores for the 
children with LD are reliably lower than the corresponding VFIQ means for the 
normative sample, both on the first occasion of testing (zBoys = 5.98; 
p < .001; zGirls = 4.82; p < .001), and at retest (zBoys = 9.58; p < .001; zGirls = 
6.65; p < .001).

For the PFIQ there is a reliable gain 
mean score for both the boys and the girls 
between test and retest, and on 
both occasions the boys return reliably higher 
mean PFIQ scores than the girls. 
Comparisons of their mean PFIQs at 
test and retest with the mean PFIQs of 
normative boys (X̄ = 102.64, SD = 
15.21) and normative girls (X̄ = 97.96, 
SD = 15.01), respectively, showed that the 
mean scores for the children with LD are 
reliably higher than the correspond- 
ing PFIQ means for the normative 
sample, both at first test (zBoys = 4.04, 
p < .001; zGirls = 2.62, p < .02) and at 
retest (zBoys = 7.66, p < .001; zGirls = 
4.78, p < .001).

DISCUSSION

The results of this study may first be 
considered in terms of the expectations 
raised by the findings of the Lawson et 
al. (1987) study.

1. (a) The behavior of the VFIQ 
scores in the cross-sectional 
study corresponds well with 
the previous results. Children 
with LD return lower scores 
than normative children, and 
their scores decline with age. 

(b) The mean PFIQ scores for the 
youngest LD age groups (i.e., 
6 and 7) were not, as had been 
expected, in this case lower 
than those of the normative 
children, but were indeed reli- 
ably higher. The scores for 
these children did, however, 
increase with age, as had been 
anticipated.

(c) As predicted, there was no sex 
difference in mean VFIQ in 
the groups with LD, but the 
boys did have reliably higher 
mean PFIQ scores than the girls.

2. The VFIQ scores in the longitudi- 
nal study were also in accord with 
expectation. Both the boys and 
the girls had lower mean VFIQ scores 
than the normative group on the 
first occasion of testing, and their 
scores also showed a reliable 
decline between test and retest, 
this in spite of the fact that in the 
interval they had all been given some 
form of remedial teaching.

Their PFIQ scores, on the other hand, 
were not quite as predicted, because 
both the boys and the girls on first 
testing had higher mean PFIQ scores 
than the children in the normative 
sample. Their PFIQ scores did, however, 
show the anticipated increase at retest.

The main difference in outcome 
between the original investigation by 
Lawson et al. (1987) and the present 
study was thus found in the mean 
PFIQs, which (in terms of both the 
cross-sectional and longitudinal data) 
proved in this case to be reliably higher 
in the children with LD than in the 
normative sample. It is, however, possible 
that this finding simply reflects the fact 
that the children in the present study 
came mainly from middle and upper 
middle class backgrounds, and might therefore have been expected to score at 
a higher level on that component of int- 
elligence thought to be unaffected by 
learning disability. Thus, while the de- 
pressed VFIQ characterizes their learn- 
ing disability, the elevated PFIQ reflects 
their higher socioeconomic status.

These results again speak to the ques- 
tion of whether learning disabilities can

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**TABLE 2**

Longitudinal Data: Means and Standard Deviations of Verbal Factorial IQs (VFIQs) and Performance Factorial IQs (PFIQs) at Test and Retest for 224 Children with Learning Difficulties and Tests of Significance of the Differences Between Mean Scores

<table>
<thead>
<tr>
<th></th>
<th>Test N</th>
<th>Test X̄</th>
<th>Test SD</th>
<th>Retest N</th>
<th>Retest X̄</th>
<th>Retest SD</th>
<th>Test vs Retest df</th>
<th>t</th>
<th>p</th>
<th>Test X̄</th>
<th>Test SD</th>
<th>Retest X̄</th>
<th>Retest SD</th>
<th>Test vs Retest df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>161</td>
<td>91.77</td>
<td>12.07</td>
<td>87.30</td>
<td>12.92</td>
<td>160</td>
<td>4.61</td>
<td>.001</td>
<td>107.48</td>
<td>13.24</td>
<td>111.82</td>
<td>13.22</td>
<td>160</td>
<td>4.51</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>63</td>
<td>92.42</td>
<td>13.69</td>
<td>89.13</td>
<td>12.49</td>
<td>62</td>
<td>2.28</td>
<td>.025</td>
<td>102.91</td>
<td>12.88</td>
<td>107.01</td>
<td>14.47</td>
<td>62</td>
<td>3.17</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>224</td>
<td>91.95</td>
<td>12.52</td>
<td>87.82</td>
<td>12.80</td>
<td>223</td>
<td>5.13</td>
<td>.001</td>
<td>106.19</td>
<td>13.27</td>
<td>110.47</td>
<td>13.72</td>
<td>223</td>
<td>5.48</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>222</td>
<td>0.35 (ns)</td>
<td>0.96 (ns)</td>
<td></td>
<td></td>
<td></td>
<td>2.34 (&lt;.02)</td>
<td></td>
<td></td>
<td>2.38 (&lt;.01)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
best be regarded as the result of developmental lag or as the product of a deficit (Rourke, 1976). The notion of developmental lag (Satz & Van Nostrand, 1973) suggests that these children resemble younger normative children, so that with the passage of time they may be expected to develop normal abilities and attainments. The deficit hypothesis (Rourke & Telegdy, 1971), however, implies that such children may have a kind of cognitive handicap from which they may never fully recover.

The present results, like those of Lawson et al. (1987), suggest that the validity of each of these hypotheses depends on the kind of cognitive ability that is being measured. The developmental lag hypothesis accords better with the chronological changes found in PFIQ. Such nonverbal ability in these children is relatively low at about age 6, but continues to develop, in the present instance up to about 9 years of age. In the case of verbal ability (VFIQ), the deficit hypothesis seems to apply. Thus, at age 6 these children already lie below their normal peers, and continue to fall behind them thereafter.

Such curious patterns of decline and growth in verbal and nonverbal abilities, respectively, raise questions about the processes that may underlie such cognitive changes in LD children. We can, at this time, only indulge in the kind of speculation that we have adumbrated elsewhere (Tittemore, Lawson, & Inglis, 1987). It may be that because there is a deficit of verbal ability in such children, they come to rely more heavily on nonverbal ability. Such exercise of one kind of ability at the expense of the other may lead to its greater development, and even to its overdevelopment. Just as a paraplegic's arm muscles become hypertrophied from their use in compensation for defective control of the lower limbs, so may intact nonverbal processing come to supplement and supersede verbal processing in these children.

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