WISC-R subtest variability in normal Canadian children and its relationship to sex, age, and IQ

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ABSTRACT

Ninety-one normal Canadian children, screened for absence of emotional and educational disabilities, were tested on the WISC-R and examined for significant subtest variability. Arithmetic, Digit Recall, Comprehension, and Coding differed significantly from the grand mean of all subtests. In a second analysis, subtest variability was examined relative to examinee sex, age, and overall IQ. Sex differences occurred on Information, Picture Completion, Arithmetic, Coding, and Digit Recall. Age differences occurred on Information and (marginally) on Performance IQ. Sex and Age interacted on performance IQ, and Sex and IQ interacted on Coding. Based on these differences, it is suggested that the absence of sex-specific norms and separate norms for Canadian children may lessen the clinical interpretability of subtest differences on the WISC-R.

Since its publication in 1974, the Revised Wechsler Intelligence Scale for Children (WISC-R) has received wide acclaim as an improved instrument for evaluating the intelligence of children. The WISC-R is also considered by some authors, on the basis of scatter and of recategorization of subtest scores, to be an untapped source in its potential for diagnosing reading and learning disabilities (Kaufman, 1975; Smith, Coleman, Dokecki, & Davis, 1977a; 1977b), and other dysfunctional behaviors (Dean, 1977; 1978). However, Kaufman (1976), after analyzing the incidence of scatter in the standardization sample, cautioned that it occurs much more frequently with normal children than test users realize. As one of the early users of the WISC-R with Canadian children, the senior author became puzzled by the seemingly inexplicable variability in subtest scores as it occurred in the individual profiles of otherwise normal children. It was not evident whether this scatter could be interpreted as typical for normal children, as reflective of problematic behaviors, or indeed, as a particular characteristic of Canadian children.

Most studies with the WISC-R have been conducted with either the normative sample, or with dysfunctional groups. Relatively few have described the functioning of "normal" groups, and fewer still have involved Canadian children. Vernon (1976, 1977) reported on two clinically referred Canadian samples, where several parts of the WISC-R scale were found to be anomalous. Peters (1976), in his comparison of Canadian children with the normative American group, cited both subtest sex differences and a tendency for the total scale to overestimate the abilities of younger children.

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Sex differences in the specific abilities measured by the Wechsler scales have been described for both children and adults in a number of earlier studies. Differences which have been reported for the more global IQ indices have generally been considered to be too small to be of practical significance. For example, significant sex differences in 8 of 11 subtests were found for the normative Wechsler Adult Intelligence Scale (WAIS) population, but because differences in global IQ indices were negligible, separate sex norms were not presented (Matarazzo, 1972). In an analysis of the WISC-R normative population, Kaufman and Doppelt (1976) reported significant sex differences favoring boys on Verbal and Full Scale IQs, but again, these differences were not thought to be meaningful in a practical sense. However, in studies evaluating sex differences in individual subtests, some consistent trends have appeared. Turner and Willerman (1977), using a group of normal adoptive parents, found that males scored significantly higher on the WAIS Information, Arithmetic, Picture Completion, and Block Design subtests, while females did significantly better on the Digit Symbol (Coding) subtest. A small but significantly higher male Full Scale IQ was considered negligible by the authors. In a study using a sample of 300 normal Canadian children, Peters (1976) found differences favoring boys at different age levels on the Information, Arithmetic, and Comprehension subtests, and favoring girls at all age levels on the Coding subtest. Although the differences were not always significant statistically, boys at different ages tended to do better on Verbal IQs and girls on Performance IQs. No sex differences in subtest scores were found for a group of learning disabled children (Vance, Gaynor, & Coleman, 1976), but the sample may have been too small (42 boys and 16 girls) to reveal them. In two recent studies reporting sex differences for retarded populations (Vance, 1979; Vance, Hankins, Wallbrown, Engin, & McGee, 1978), males scored higher than females on the majority of the subtests, with Comprehension and Object Assembly favoring males and Coding favoring females to significant levels. As well, male Verbal IQs were higher than those of females in both studies, reaching significance in one. Similar findings with retarded populations were reported earlier using the Wechsler Intelligence Scale for Children (Alper, 1967; Gainer, 1965), with males generally performing better on most of the subtests, and females always better on the Coding test. In a study where global IQ scores were compared, however, sex differences were not found (Finley & Thompson, 1959). Finally, Lyle and Johnson (1974) reported significant sex differences favoring females in the performance of the WISC Coding subtest by a group of 85 normal 4th graders.

The trends emerging from a review of these studies suggest that males find the Information, Comprehension, Arithmetic, and Picture Completion tasks somewhat easier than females, and generally tend to attain higher Verbal IQ scores. Females, on the other hand, scored significantly higher on the Coding task in all studies with the exception of one study where the sample size was small (Vance et al., 1976). It is suggested that the occurrence of persistent sex differences in specific subtest scores would have implications where individual strengths and weaknesses are being evaluated. For example, since the majority of children identified as learning disabled are boys (Anderson, Kaufman, & Kaufman, 1976; Smith et al., 1977a; 1977b; Vance et al., 1976), the scatter typically associated with their behaviors might not have the same diagnostic implications if same sex, rather than combined sex, norms were available.

The purpose of the present study was twofold: (1) to describe the cognitive characteristics of a randomly selected group of normal Canadian children using the WISC-R; and (2) to analyze the relationship between variability in scores and examinee characteristics of sex, age, and intellectual level. If Canadian children do, in fact, demonstrate systematic variability in subtest scores that may be related to their sex, age, or intellectual level, then it is suggested that the criteria generally used to describe problematic behaviors may have to be reevaluated when applied to Canadian children.

METHOD

Subjects

The participants in this study were a group of 91 normal Canadian children tested with the WISC-R by graduate Clinical Psychology students enrolled in an Individual Assessment course co-taught by the senior author between 1975 and 1979. All students had prior experience with testing young children and with technical administration of the WISC-R. The scoring of each individual protocol was personally supervised by the senior author. Subjects were volunteered in response to letters sent to parents in randomly selected schools in two school divisions in Winnipeg, as well as through neighborhood solicitation by graduate students. Children with known emotional, retardation, or learning problems were excluded, as were test protocols that were inadequately administered. While these subjects cannot be considered representative of Canadian children, all were volunteered, normal children drawn from predominantly middle class areas. The sample was comprised of 43 females and 48 males with an age range from 8-0 to 16-10 (mean age = 11-5) and a WISC-R Full Scale IQ range from 78 to 152 (mean IQ = 115.5).

Procedure

The WISC-R was administered to each child in the standard order presented in the manual (Wechsler, 1974). The Mazes subtest was excluded. Of the 91 children, 77 were given the optional Digit Recall subtest.

Data analysis was done in two phases. In order to evaluate subtest variability in the total group, a one-sample Hotelling T^2 analysis was employed (Tatsuoka, 1971), comparing all subtest scores to the relevant subtest grand mean and controlling for the inter-correlation between subtests. Specifically, the means of the five subtests of the Verbal Scale were compared with the Verbal subtest grand mean (excluding Digit Recall), followed by a comparison of the Digit Recall subtest ($N = 77$) with this same mean. The means of the five Performance subtests were similarly compared with the Performance subtest grand mean. Verbal and Performance scales were analyzed separately because of strong empirical support for interpreting these scales as functional unities with both normal and dysfunctional groups. (Kaufman, 1975; Lombard & Riedel, 1978; Schooler, Beebe, & Koepke, 1978; Wallbrown, Blaha, Wallbrown, & Engin, 1975).

In order to examine the relationship between subtest variability and subject characteristics of sex, age, and IQ, a second analysis was done. The total sample was dichotomized on the basis of sex (M,F),

TABLE 1
Means, standard deviations, and p values of the deviations from the grand mean for WISC-R Verbal and Performance scaled scores

	Mean	*SD*	p value of deviations from the grand mean
Infor	11.89	2.83	.510
Sim	12.46	3.15	.258
Arith	11.27	3.00	.012
Vocab	12.20	2.46	.666
Comp	12.60	2.70	.070
(D Rec)	(11.32)	(3.34)	(.049)
P Com	12.49	2.60	.269
P Arr	12.58	2.56	.149
B Des	12.15	3.08	.906
O Asm	12.63	3.05	.177
Cod	11.11	2.71	.001
VIQ	112.6	9.36	
PIQ	115.4	10.02	
FSIQ	115.5	8.83	

Note. Verbal scaled score grand mean (excluding D Rec) = 12.086. Performance scaled score grand mean = 12.192.

age (Older = 12-0 to 16-11, mean age = 13-8; Younger = 8-0 to 11-11, mean age = 9-9), and IQ (Higher = ≥ 115; Lower = ≤ 114). Three 2 × 2 × 2 multivariate analyses of variance (MANOVAS) were then performed with Verbal subtest scales, Performance subtest scales, and Verbal-Performance IQ scores as dependent variables. The Digit Recall subtest, because of its inclusion in various factorial studies (Kaufman, 1975; Wallbrown et al., 1975), was included, thereby reducing the number of subjects to 77 in the Verbal scale analysis. Finally, a single 2 × 2 × 2 univariate analysis of variance (ANOVA) was done on the Full Scale IQ scores. Where significant interactions were demonstrated, a test for simple effects was employed to assess differences between means.

RESULTS

As is apparent from Table 1, the mean IQ scores of this group of Canadian children exceed those of the normative American population (Wechsler, 1974), and probably reflect the middle-class background from which these children were drawn (Loehlin, Lindzey, & Spuhler, 1975). A Hotelling T^2 analysis of the Verbal Scale revealed a significant multivariate main effect of subtest differences, $F_m\,(5,86) = 3.350$, $p < .008$, indicating that when all Verbal subtests were considered simultaneously, there were significant differences between individual subtests and the grand mean of all Verbal subtests. Considering each subtest separately, Arithmetic was significantly lower, $t\,(90) = -2.58$, $p < .012$, and Comprehension tended to be higher, $t\,(90) = 1.83$, $p < .070$, than the mean value for all Verbal subtests. Digit Recall was significantly lower, $t\,(76) = -2.00$, $p < .049$, than the Verbal mean. Similarly, for the Performance Scale, a significant

TABLE 2

Mean WISC-R Verbal scaled scores, Performance scaled scores, and Verbal, Performance, and Full Scale IQs for Sex, Age, and IQ

	Sex[a]		Age[b]		IQ[c]	
	Female	Male	Older	Younger	Higher	Lower
Infor	11.32	12.40	12.49	11.38	13.45	10.00
Sim	12.19	12.90	12.33	12.83	14.52	10.20
Arith	10.59	11.65	11.20	11.10	12.45	9.57
Vocab	12.05	12.30	11.83	12.48	13.40	10.71
Comp	13.03	12.40	12.91	12.52	14.12	11.00
D Rec	11.92	10.77	11.57	11.12	12.07	10.43
P Com	12.02	12.92	12.72	12.33	13.60	11.15
P Arr	12.56	12.60	12.49	12.65	13.58	11.37
B Des	11.86	12.42	11.74	12.46	13.36	10.68
O Asm	12.51	12.73	12.10	13.02	14.18	10.73
Cod	11.84	10.46	10.67	11.44	12.02	10.00
VIQ	110.7	114.3	113.3	112.1	121.5	101.7
PIQ	115.0	115.8	113.4	116.9	123.9	105.0
FSIQ	114.1	116.8	114.9	115.9	125.5	103.3

[a]*N*: females = 43, males = 48 (Verbal group *N*: females = 37, males = 40).
[b]*N*: older = 39, younger = 52 (Verbal group *N*: older = 35, younger = 42).
[c]*N*: higher IQ = 50, lower IQ = 41 (Verbal group *N*: higher IQ = 42, lower IQ = 35).

multivariate main effect occurred for subtest differences, F_m (5,86) = 4.851, $p < .001$. Considering each Performance subtest independently, Coding was significantly lower, t (90) = −3.82, $p < .001$, than the mean value for all Performance subtests. It appears, then, that the distribution of scaled scores for this sample of Canadian children is more scattered than that of the American normative population, whose normalized scaled scores, by definition, contributed equally to total IQ scores (Wechsler, 1974).

Table 2 presents the mean values for all WISC-R subtests and for the Verbal, Performance, and Full Scale IQs across sex, age, and IQ. These variables were found to interact in varying degrees to affect scores. Significant findings will be discussed separately.

Intelligence Quotient

As expected, and almost by definition, multivariate analysis of variance indicated that brighter subjects did better than less bright subjects on all Verbal and Performance subtests, and on Verbal, Performance, and Full Scale IQs. All main effects and subtest differences were significant at $p < .0001$, with the exception of Digit Recall which was significant at $p < .017$.

Sex

A significant multivariate main effect was found for both the Verbal subtests (including Digit Recall), F_m (6,64) = 2.774, $p < .020$, and the Performance subtests, F_m (5,79) = 2.902, $p < .019$, indicating that, for this Canadian sample, sex of the subject influenced subtest scores. When each subtest was considered independently, boys' scores exceeded those of girls on Information, $F(1,69) = 5.052$, $p < .028$, and tended to exceed girls' on Picture Completion, $F(1,83) = 3.389$, $p < .069$, and Arithmetic, $F(1,69) = 2.836$, $p < .097$. Conversely, girls' scores exceeded those of boys on Coding, $F(1,83) = 7.772$, $p < .007$, and tended to exceed boys' on Digit Recall, $F(1,69) = 2.380$, $p < .128$. It is interesting that, while boys scored higher than girls on 8 of the 11 subtests, as well as on the Verbal, Performance, and Full Scale IQs, these differences did not translate into statistically significant main effects of sex for the Verbal vs. Performance IQs, F_m (2,82) = 1.693, $p < .190$, or for the Full Scale IQs, $F(1,83) = 2.153$, $p < .146$.

Age

A significant multivariate main effect was found for Verbal subtests, F_m (6,64) = 2.727, $p < .020$. When subtests were considered separately, older subjects did better than younger subjects on the Information subtest, $F(1,69) = 6.623$, $p < .012$. No multivariate main effect of age was demonstrated for Performance subtests, F_m (5,79) = 1.325, $p < .262$. A marginally significant main effect of age was found in the Verbal vs. Performance IQ analysis, F_m (2,82) = 2.496, $p < .089$, with younger subjects tending to score higher (M = 116.9) than older subjects (M = 113.4) on Performance IQ, $F(1,83) = 2.606$, $p < .110$.

Sex × IQ

A significant multivariate interaction was found for Performance subtests, F_m (5,79) = 2.565, $p < .033$, but not for Verbal subtests, F_m (6,64) = 0.516, $p < .794$. Examining the Performance subtests individually, sex and IQ interacted to affect the Coding subtest, $F(1,83) = 3.968$, $p < .050$, and tended to interact to affect the Object Assembly subtest, $F(1,83) = 2.790$, $p < .099$. Simple effects analysis revealed that bright females performed better on Coding than both bright males, $F(1,83) = 11.82$, $p < .01$, and less bright females, $F(1,83) = 19.35$, $p < .001$. Thus, bright males did significantly more poorly on Coding than did bright females (M = 11.00 vs. 13.43, respectively), yet did not appear significantly different in their Coding scores from either less bright males (M = 9.63) or less bright females (M = 10.32). In the trend for sex × IQ interaction to affect Object Assembly scores, however, no simple effects approached significance.

Sex × Age

A significant multivariate interaction of sex × age was demonstrated for Verbal vs. Performance IQs, F_m (2,82) = 3.228, $p < .045$. When considered separately, age interacted with sex to affect Performance IQ, $F(1,83) = 3.655$, $p < .059$. Simple effects analysis indicated that older males scored lower on Performance IQ than either older females, $F(1,83) = 4.91$, $p < .05$, or younger males, $F(1,83) = 10.078$, $p < .01$. The mean PIQ score for the older males was 109.8, contrasted to a mean PIQ of 116.5 for older females, and 119.4 for younger males.

Sex × Age × IQ
No significant interaction was found.

DISCUSSION

The first phase of the present study revealed significant subtest variability in the WISC-R protocols of a group of non-referred, and presumably non-clinical, Canadian children. Arithmetic and Digit Recall were found to be significantly lower than the mean value of all Verbal subtests, while Comprehension tended to be higher. Coding was considerably lower than the mean of all Performance subtests. These findings are consistent, to some extent, with those of Vernon (1976, 1977) who reported that for three samples of Canadian children referred for special educational services, the WISC-R Digit Recall and Coding subtests appeared to be significantly more difficult than their counterparts on a WISC scale administered earlier for one sample, and the remainder of the WISC-R Verbal and Performance subtests, respectively, for all three samples. For all of Vernon's samples the WISC-R Digit Recall and Coding subtests ranged from one and one-half to two points lower than the remainder of their subtest scores. Vernon suggested that the placement of these two subtests at the end of the scale may have resulted in either fatigue or distractibility affecting the scores of these clinically referred children. He also suggested that a change to a color format may have accounted for the lagging Coding scores. However, this explanation may be questioned in view of a more recent investigation. (Lombard & Riedel, 1978) in which the change to a color format was reported as having the opposite effect, i.e., of enhancing Coding raw and scaled scores.

Of particular interest is the finding that the present sample of normal children scored significantly lower on those subtests (Arithmetic, Digit Recall, and Coding) that contribute substantially to a factor described as "Freedom from Distractibility" for the normative sample (Kaufman, 1975), retarded children, and adolescents (Van Hagen & Kaufman, 1975), and other dysfunctional groups (Schooler et al., 1978). More recently these same three subtests have been employed in a recategorized format as part of a system to identify children with genetic dyslexia and other learning disabilities (Smith et al., 1977b), and guidelines have been provided for determining minimum differences in scaled score points required for an individual child to be classified as a disabled learner (White, 1979). The reasons for the decrease in these particular subtest scores in the present study are not immediately clear. It may simply reflect a bias in terms of the types of children volunteered by their parents for testing by University students, and the fact that this normal group demonstrates some of the same kinds of attentional problems as do referred children. Whatever the reason, the finding that a non-referred group of middle-class Canadian children without any identified educational or emotional problems performed consistently less effectively on the particular subtests mentioned above should alert the Canadian practitioner using these indices to the possibility of misclassifying children as being more dysfunctional in attentional areas than may actually be the case.

The second phase of the present study assessed the relationship between subtest variability and examinee characteristics of sex, age, and IQ. The discovery that WISC-R subtest scores were affected by the sex of the examinee was not altogether unexpected, given the sex differences already reported with normal adults and with both normal and dysfunctional groups of children. For this normal Canadian sample, the mean scores of boys exceeded those of girls for 8 of 11 subtests, reaching statistical significance on the Information, Picture Completion, and Arithmetic subtests. Girls' scores significantly exceeded those of boys on the Coding and Digit Recall subtests, but not significantly on the Comprehension subtest. Boys also exceeded girls on Verbal, Performance, and Full Scale IQs, although significant main effects of sex were not demonstrated for these more global indices of intellectual functioning. This, again, is consistent with the findings of other studies where sex differences affecting global IQ indices were either non-existent or else considered too small to be of practical importance (Finley & Thompson, 1959; Kaufman & Doppelt, 1976; Matarazzo, 1972; Turner & Willerman, 1977). Of interest, in relation to the present study, is the finding that while sex differences were clearly demonstrated for some specific abilities measured by the Wechsler scale, they tended to be obliterated when scores were converted to the more global indices of intellectual functioning. However, because it is not only the global IQ scores that are considered in the assessment of dysfunctional behaviors, but also the relationships amongst the individual subtest scores or groupings of subtest scores, it is the authors' view that sex, for example, should not be disregarded when evaluating a child's functioning. If boys and girls deal with cognitive tasks in different ways, these differences may become confounded when norms based on combined sex groups are the basis for evaluating individual strengths and weaknesses. For example, in the present sample, using the Coding and Digit Recall (but not Arithmetic) subtests as indices of attentional difficulties or anxiety, the inclination might be to describe boys as having more difficulty in attending to rote material, or being more anxious, when comparing them to *combined* sex norms, than would be the case with *same* sex norms. On the basis of their lowered Information and Picture Completion scores, girls might be described as being less alert to environmental details than is justified when combined rather than same sex norms are used.

The Coding subtest has consistently differentiated males and females in all earlier studies, with the exception of one (Vance et al., 1976). The present study reveals some interesting interactions with respect to this task. Sex of the subject, in addition to differentially affecting the Coding scores, also interacted with IQ to affect these scores; bright males performed more poorly than bright females, but not differently than less bright males or females. Thus, not only did boys as a group find the Coding task more difficult than did girls, but brighter boys in particular performed more poorly than expected. A possible explanation may be that boys in general, and especially bright boys, find this task less interesting than do girls. The recently revised norms for the WISC-R Coding task, which now require more efficiency of older brighter children (Sattler, 1974) may also have differentially affected boys' scores. Further research into the relationship of sex and intelligence with respect to the Coding subtest is necessary in order to determine whether the findings of the present study can be generalized to other groups.

Age was found to affect the outcome of individual Verbal subtests, with older subjects scoring significantly higher on the Information subtest. Age was also marginally related to Verbal and Performance IQs, with the younger group tending to score higher than the older group on Performance IQs. Additionally age was found to interact with sex when considering Verbal and Performance IQs, with older males achieving Performance IQ scores which were almost 10 points lower than those of younger males, and almost 7 points lower than those of older females. Peters (1976) reported a gradual decline in global IQ indices, as well as in 9 of 10 subtest scores, as age increased for his group of normal Canadian children. In the present study age was found to be related to specific abilities and to global IQ indices somewhat differentially, i.e., affecting individual Verbal subtests but not Verbal IQs and Performance IQs but not individual Performance subtests. It becomes difficult, therefore, to attach any particular significance to these age-related findings, other than suggesting that the abilities of older boys may be somewhat underestimated by the Performance scale.

While the authors acknowledge that the non-clinical sample employed in this study may not necessarily be representative of Canadian children, the findings nevertheless raise some interesting questions concerning the applicability of American norms to Canadian children, especially with regard to the interpretation of subtest scatter. First, the total group showed some subtest characteristics similar to those described for distractible or learning disabled children. Whether these results are spurious or, indeed, a characteristic of Canadian children should be further investigated with carefully selected groups of normal Canadian children. The implication of these findings is that the criteria generally used to describe problematic behaviors may have to be reevaluated when applied to Canadian children.

Secondly, the present study suggests that sex and age are both directly and interactively related to cognitive functioning. Although this investigation does not support the hypothesis that sex affects global IQ indices, it strongly supports the findings of other investigators that males and females differ in some specific abilities measured by the Wechsler scales, with the majority of these differences favoring males. Whatever their source, the fact that these differences do exist should be acknowledged when evaluating individual strengths and weaknesses. The Coding task, which has had the most consistent history of favoring females, was demonstrated to penalize brighter boys in particular. Finally, the Performance abilities of older children, and especially older boys, may be somewhat underestimated by the scale. The authors suggest that the evidence for sex and age differences in cognitive functioning is too strong to be ignored by either American or Canadian practitioners using the Wechsler scales. On this basis, the provision of separate norms may be indicated.

RÉSUMÉ

Des enfants canadiens normaux ($n = 91$), sans accuser des insuffisances d'ordre émotif ou scolaire, sont soumis à l'épreuve d'intelligence WISC-R. Quand on cherche ensuite s'il existe des différences significatives entre les divers sous-tests pour l'ensemble du groupe, on en trouve pour différents sous-tests (arithmétique, mémoire de chiffres, compréhension, substitution), et cette variabilité est liée au sexe, à l'âge et au QI général. Des différences liées au sexe s'observent dans les sous-tests information, complètement d'images, arithmétique, substitution, et mémoire de chiffres. On trouve des différences liées à l'âge au sous-test information et, marginalement, au QI non verbal. Il existe une interaction sexe-âge au QI non verbal et une interaction sexe-QI au sous-test substitution. Ces différences suggèrent que l'absence de normes spécifiques au sexe et de normes particulières pour les enfants canadiens risque de diminuer la possibilité d'une interprétation clinique de la variabilité des sous-tests dans l'épreuve WISC-R.

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