

Short-forms of the UK WAIS-R: Regression equations and their predictive validity in a general population sample

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A sample of 200 healthy subjects, representative of the adult UK population in terms of age, sex and social class distribution, were administered a full-length WAIS-R (UK). Regression equations were built to predict full-length IQ from a series of short-forms. The short-forms ranged from a two-subtest version proposed by Silverstein (1982) to a seven-subtest version proposed by Warrington, James & Maciejewski (1986). Regression equations, their standard errors of estimate and confidence intervals are presented as well as IQ conversion tables. The short-forms are evaluated in terms of their validity in predicting full-length IQ and in terms of their clinical utility. The advantages of regression-based estimates of full-length IQ over those derived from conventional prorating are discussed.

It is to be expected that the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981) will become the major instrument for the assessment of intellectual abilities and intellectual impairment in the UK. However, although a UK version is now available (Lea, 1986), the WAIS—R has not been standardized in this country. Because of this, it is necessary to examine its psychometric properties in UK samples. In the present authors' view, this work should be conducted with samples of the general adult population before turning attention to clinical populations. Although some information on the properties of the WAIS—R (UK) is now beginning to appear (e.g. Crawford, Allan, Besson, Cochrane & Stewart, 1990; Crawford, Allan, Stephen, Parker & Besson, 1989), a large number of issues remain to be examined.

A particularly useful exercise would be to develop UK short-forms of the WAIS—R and examine the accuracy with which they predict full-length IQ. Holmes, Armstrong, Johnson & Ries (1965) estimated that in the US, short-forms of the Wechsler scales are administered in over 80 per cent of cases. Although a straw poll suggests that this figure is an overestimate for UK clinicians, there can be little doubt that heavy caseloads frequently necessitate the use of short-forms.

The various proposed short-forms of the Wechsler scales can be divided into two categories: those (e.g. Satz & Mogel, 1962) where all subtests are administered but

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in a shortened form (i.e. only every second or third item) and the more common approach of administering a subset of the 11 subtests. The present study will be limited to an examination of the latter approach. The proposed short-forms are presented in Table 1. These vary in length from Silverstein's (1982) two-subtest short-form to the seven-subtest short-form used by Warrington and her colleagues (e.g. Warrington, James & Maciejewski, 1986). The first three, i.e. Silverstein's two- and four-subtest versions and Reynolds, Willson & Clark's (1983) four-subtest version, were all developed specifically for predicting full-length WAIS—R IQs in the US. Of the remaining four, Britton & Savage's (1966) and Warrington's short-form were originally developed in the UK for the WAIS. Britton & Savage developed their short-form specifically for use with the elderly (hence the subtests make less demands on visual acuity than those omitted). Warrington's short-form has been used in a large number of studies employing the WAIS, e.g. it was used in standardizing the National Adult Reading Test (NART: Nelson, 1982). Finally, four- and six-subtest versions proposed by the present authors will also be examined.

Table 1. Proposed short-forms of the WAIS—R

Author	Subtests	
	Verbal	Performance
Silverstein (1982)	Vocabulary	Block Design
Silverstein (1982)	Vocabulary Arithmetic	Block Design Picture Arrangement
Reynolds, Willson & Clark (1983)	Information Arithmetic	Block Design Picture Completion
Britton & Savage (1966)	Vocabulary Comprehension	Block Design Object Assembly
Present authors	Comprehension Similarities	Block Design Object Assembly
Present authors	Comprehension Similarities Arithmetic	Block Design Object Assembly Picture Arrangement
Warrington, James & Maciejewski (1986)	Vocabulary Digit Span Arithmetic Similarities	Block Design Picture Completion Picture Arrangement

The conventional method of predicting full-length IQs from selected subtests involves converting raw subtest scores to scaled scores and then inserting the mean of these subtests for those subtests that were omitted (commonly termed prorating). The resultant sum of scaled scores is then converted to an IQ. An alternative approach is to build regression equations directly to predict full-length IQs from the sum of the administered subtests' *age-graded* scaled scores.

The latter approach has a number of advantages. Firstly, and most importantly, it is more accurate. The correlation between the selected subtests and IQs can never be unity. Therefore, subjects with extreme scores on the selected subtests will, on average, obtain less extreme IQ scores (an example of regression to the mean). In contrast to the use of linear regression, the conventional prorating method does not take this into account. Furthermore, there are large differences between subtests in the rate at which performance increases and declines across the adult age range. Therefore, for clients who lie outside the age range of the WAIS-R reference group (i.e. those below 20 and above 34) normal scaled scores for selected subtests will be relatively poor predictors of scores on omitted subtests. This problem is surmounted in the regression approach by converting raw scores to age-graded scaled scores (using the relevant tables; Wechsler, 1981, pp. 142-150). Finally, the regression approach has a practical advantage. Most clinicians, whether using the full-length Wechsler or a short-form, are not only interested in the summary IQs but also in examining a client's strengths and weaknesses on the individual subtests. Thus, when using the prorating method, raw scores must be converted to both normal scaled scores (to derive IQs) and age-graded scaled scores (to examine the subtest scatter). With the regression approach only the latter need be calculated.

Method

The sample consisted of 200 subjects (104 females, 96 males) free of neurological, psychiatric or sensory disorder. Subjects were recruited from a wide variety of sources, e.g. local and national companies, non-medical health service personnel, community centres and local clubs (pensioners' clubs, bowling clubs etc.). Most received a small honorarium for their participation. Mean age was 44.3 (SD = 19.2) with a range of 16 to 83 years and mean years of education was 12.6 (SD = 3.0) with a range of 7 to 21 years. Each subject's social class was coded from their occupation using the Office of Population Censuses & Surveys (1980) Classification of Occupations.

The social class distribution of the sample is presented in Table 2 along with the census-derived figures for the adult UK population. A goodness-of-fit chi-square test revealed that the sample proportions did not differ significantly from the adult UK population ($\chi^2(4) = 5.66$, n.s.). A similar procedure was adopted to examine the representativeness of the sample in terms of age distribution. Three arbitrary age bands were formed (16-35, 36-60, 61-83) and the proportions of the sample falling into each band were calculated. Comparison of these proportions with the census-derived proportions (see Table 3) by a goodness-of-fit test revealed that they did not differ significantly ($\chi^2(2) = 3.80$, n.s.). Finally, the sample's sex distribution was also representative of the adult UK population ($\chi^2(1) = 0.01$, n.s.).

Table 2. Social class distribution in the WAIS-R sample and adult UK population (percentages)

	1	2	3	4	5
WAIS-R sample	7	27	42	17	8
General adult UK population	5	23	48	18	6

All subjects were administered a full-length WAIS-R (UK) according to standard procedures (Lea, 1986; Wechsler, 1981). Raw scores on the 11 WAIS-R subtests were converted to normal scaled scores for the calculation of full-length FSIQ, VIQ and PIQ. Raw subtest scores were also converted to age-

Table 3. Age distribution in the standardization sample and adult UK population (percentages)

	Age distribution		
	16-35	36-60	61-83
WAIS-R sample	41	32	27
General adult UK population	39	38	23

graded scaled scores for use as predictor variables in the regression analyses. For each of the proposed short-forms, age-graded scaled scores for the relevant subtests were added together. The relevant full-length IQs (i.e. FSIQ, VIQ and PIQ) were then regressed on these totals.

Results

The subjects' mean WAIS-R Full Scale IQ was 102.5 (SD = 13.12) with a range of 71 to 140.

The results of the regression analyses are presented in Table 4. The correlations between the short-forms and full-length IQs appear in the first column. All these correlations were significant beyond the .001 level. Also presented in Table 4 are the constants and beta weights for the regression equations (see Discussion for an illustration of their use). The standard error of estimate (SE) for each equation is presented in the fourth column. The SE represents the standard deviation of scores around the regression line and is thus a measure of the error in prediction. Multiplying the SE by 1.65 and by 1.96 produces the 90 and 95 per cent confidence intervals respectively. If, to use Warrington's equation for FSIQ as an example, the 90 per cent confidence interval was 5.9, there is a 90 per cent probability that a client's full-length IQ would not differ from the predicted IQ by more than 5.9 points in either direction.

Hotelling (1940) developed a method to test for significant differences in correlations between a criterion variable (full-length IQ in the present case) and competing predictor variables. This method is appropriate when the predictor variables are themselves correlated (clearly the case in the present study). Hotelling's method was used to compare the predictive validity of Silverstein's two-subtest short-form with the poorest performing four-subtest short-form. Thus, the correlations for FSIQ, VIQ and PIQ were compared with those of the present authors (FSIQ = .90), Reynolds *et al.* (1983) (VIQ = .87), and Britton & Savage (1960)/present authors (PIQ = .84) respectively. The four-subtest FIQ and PIQ short-forms differed significantly ($p < .05$) from their two-subtest equivalents but Reynolds *et al.*'s VIQ did not. Silverstein's (1982) VIQ was therefore compared with the next poorest performing four-subtest VIQ (present authors, VIQ = .88). This yielded a significant difference ($p < .05$). Thus it can be concluded that, with the exception of Reynolds *et al.*'s VIQ, all four-subtest versions had significantly greater predictive validity than the two-subtest short-form.

The present authors' six-subtest and Warrington's seven-subtest short-forms were also compared with the best performing four-subtest short-form. For FSIQ and VIQ

Table 4. Results from the regression of full-length WAIS-R (UK) IQs on the proposed short-forms

Short-form	<i>r</i>	Constant	Beta weight	Standard error of estimate	Confidence intervals (%)	
					90	95
<i>Silverstein</i> (2 subtests)						
FSIQ	.87	46.4	2.6	6.48	10.7	12.7
VIQ	.84	55.3	4.5	6.88	11.4	13.5
PIQ	.76	61.5	3.7	8.70	14.4	17.1
<i>Silverstein</i> (4 subtests)						
FSIQ	.93	37.7	1.5	4.98	8.2	9.8
VIQ	.90	43.9	2.7	5.52	9.1	10.8
PIQ	.89	48.3	2.5	6.22	10.3	12.2
<i>Reynolds et al.</i>						
FSIQ	.92	42.6	1.4	5.09	8.4	10.0
VIQ	.87	53.7	2.3	6.25	10.3	12.2
PIQ	.90	49.2	2.5	5.95	9.8	11.7
<i>Britton & Savage</i>						
FSIQ	.91	41.0	1.5	5.55	9.2	10.9
VIQ	.88	52.8	2.4	6.00	9.9	11.8
PIQ	.84	52.4	2.4	7.20	11.9	14.1
<i>Present authors</i> (4 subtests)						
FSIQ	.90	42.9	1.5	5.70	9.4	11.2
VIQ	.88	53.9	2.4	6.10	10.1	12.0
PIQ	.84	52.4	2.4	7.20	11.9	14.1
<i>Present authors</i> (6 subtests)						
FSIQ	.95	35.2	1.1	4.14	6.8	8.1
VIQ	.93	43.7	1.9	4.65	7.7	9.1
PIQ	.93	42.3	1.9	4.89	8.1	9.6
<i>Warrington et al.</i>						
FSIQ	.96	32.9	0.9	3.58	5.9	7.0
VIQ	.95	36.8	1.5	3.87	6.4	7.6
PIQ	.94	44.0	1.8	4.69	7.7	9.2

this was Silverstein's four-subtest version (.93 and .90) and for PIQ, Reynolds *et al.*'s version (.90). All comparisons yielded differences that were significant at the .01 level or beyond. Thus, it can be concluded that the six- and seven-subtest short-forms had significantly greater predictive validity than all four-subtest short-forms.

Discussion

Ideally, when using the WAIS—R, the full-length version should be administered. However, the realities of clinical work are such that short-forms will be employed

because of heavy caseloads. Short-forms have a valid role in the initial screening of clients and when a broad estimate of a client's intellectual ability is all that is required. Furthermore, they would have a role when, because of fatigue or a negative attitude to testing, a client is unlikely successfully to complete the full-length version.

In the present authors' view, short-forms can also be usefully employed in neuropsychological assessment. Most authorities (e.g. Lezak, 1983) continue to view the Wechsler as the core measure in neuropsychological assessment. However, whether adopting a battery-based or hypothetico-deductive approach to the assessment process, a considerable number of additional measures must be administered (i.e. measures of memory functions, executive functions etc.). Given limited time, it would be advisable to administer a short-form rather than neglect to examine those cognitive functions not assessed by the WAIS-R. If equivocal results are obtained with the short-form then as Reynolds *et al.* point out, the omitted subtests can be administered at a later stage.

With regard to neuropsychological applications, the reader may be surprised that none of the short-forms examined here have incorporated Digit Symbol, given that it has proved to be particularly sensitive to cerebral dysfunction (Lezak, 1983). However, Digit Symbol is the poorest predictor of performance on the other WAIS-R subtests (e.g. in factor analytic studies it has the lowest loading; Crawford *et al.*, 1989). In the case of the present authors' four- and six-subtest short-forms, there was no appreciable improvement in the prediction of FSIQ when Digit Symbol scores were included in the regression analyses. Thus, little is to be gained from presenting an equation which incorporates Digit Symbol, although given its sensitivity, it would still be appropriate to administer this subtest in its own right as part of a neuropsychological assessment.

In neuropsychological applications, short-forms based on selected subtests have an advantage over Satz—Mogel type procedures (where all subtests are administered but in a shortened form). With the former approach it is still possible to examine subtest scatter, albeit on a lesser number of subtests. With the latter approach, the drastic reduction in the length of the subtests will reduce their reliability to a level where interpretation of subtest differences would be very inadvisable.

It was noted at the beginning of this paper that, because of regression to the mean, estimates of full-length IQ derived from a regression equation will necessarily be more accurate than estimates obtained by conventional prorating. Two factors will determine the extent to which a prorated estimate deviates from a regression-based estimate. Firstly, it will vary inversely with the size of the correlation between the selected subtests and full-length IQ. Thus, the most serious deviations will occur with Silverstein's two-subtest short-form and the least serious with the six- and seven-subtest short-forms. Secondly, the deviation will be larger the further the client's scores on the selected subtests are from the population means. For clients who score markedly below the population mean prorating will, on average, *underestimate* the full-length IQ whereas it will *overestimate* full-length IQ in those who score markedly above the population mean. The extent of this error in prediction can be considerable. Take the example of a subject who obtains raw scores on the Vocabulary and Comprehension subtests of 67 and 30 respectively. To permit a direct comparison between the two methods, let us suppose that the client's age lies

in the 25—34 age band (in this age band the normal and age-graded scaled scores are the same). The above raw scores convert to normal and age-graded scores of 16 for both tests. Entering the sum of these scores into the equation for Britton & Savage's VIQ yields an estimated IQ of 130 (rounded). The estimated IQ for this subject obtained by conventional prorating is 144, essentially a standard deviation higher than the regression-based estimate.

Choosing between the different short-forms evaluated in this study would be partly a matter of personal preference. However, the present authors can envisage very few clinical situations where the two-subtest short-form would be acceptable. In addition, the six- and seven-subtest versions were superior to the four-subtest versions and should therefore be used if time permits.

Consideration will now be given to the relative pros and cons of the four-subtest short-forms. Reynolds *et al.* (1983) have noted that almost all US studies of WAIS and WAIS-R short-forms have used the correlation with full-length IQ as the sole criterion for evaluating competing short-forms. If this was to be used as the sole criterion in the present case then, amongst the four-subtest short-forms, Silverstein's (1982) version would be the method of choice in the UK. However, other psychometric factors, as well as practical considerations should have a role in any evaluation. For example, the four-subtest short-forms proposed by Britton & Savage (1966) and the present authors have a significantly lower correlation with PIQ than those of Silverstein and Reynolds *et al.* However, these former short-forms can be viewed as possessing superior *factorial* validity. Factor analytic studies of the WAIS-R in both US and UK samples have extracted a 'verbal' factor, on which Information, Comprehension, Vocabulary and Similarities all load highly, and a 'perceptual organization' factor on which Block Design and Object Assembly have the highest loadings (see Crawford *et al.*, 1989; Crawford, Jack, Morrison, Allan & Nelson, 1990). All four short-forms have high construct validity as measures of the verbal factor, with the exception of that of Reynolds *et al.* Arithmetic has a low loading on the verbal factor and indeed some studies have found that this subtest, together with Digit Span, defines a third factor commonly termed 'freedom from distractibility' (see Leckliter, Matarazzo & Silverstein, 1986, for a review). The selection of Block Design and Object Assembly in the Britton & Savage and present authors' short-forms confers superior validity on these short-forms as measures of the 'perceptual organization' factor. These short-forms also have a practical advantage in that they would be suitable for use with the elderly and other populations where there is an increased probability of impaired visual acuity.

The short-form proposed by the present authors differs from Britton & Savage's only in the replacement of Vocabulary with Similarities. A decision between these two short-forms would depend on the reason for assessment. Vocabulary has been a commonly employed subtest in short-form construction because it has the highest correlation with FSIQ (see Wechsler, 1981, p. 46). If the aim was to assess the intellectual level of a client in whom the possibility of acquired impairment was not an issue then, on the above basis, Britton & Savage's short-form would be preferred. However, were the aim to detect and quantify possible impairment of intellectual functioning, then the present authors' short-form may be more appropriate. Until recently, Vocabulary was widely used as a measure of premorbid intelligence (Lezak,

1983). Vocabulary scores were compared with scores on subtests more sensitive to impairment (e.g. Similarities, which makes more demands on abstraction) in an attempt to detect a decline from a previously higher level of functioning. However, although Vocabulary has proved to be amongst the most robust of the Wechsler subtests, it has consistently proved inferior as a measure of premorbid intelligence when compared with more recent instruments such as the NART (see Crawford, 1989, for review). Thus Vocabulary can be viewed as falling between two stools; it is not particularly impairment sensitive (and so will be less likely to detect deficits) yet is less robust than the NART (and so will tend to underestimate *premorbid* IQ).

The constants and beta weights presented in Table 4 should be used to obtain predicted full-length IQs. This is best illustrated by example. If Reynolds *et al.*'s (1983) short-form is to be used to predict FSIQ, then the Information, Arithmetic, Block Design and Picture Completion subtests should be administered and the age-graded scaled scores for each of the subtests added together. Tables for converting raw subtest scores to age-graded scaled scores are presented in the WAIS—R manual (Wechsler, 1981, pp. 142—150). Take the example of a client who obtained age-graded scaled scores of 12, 15, 13 and 14 on the four subtests. Adding these together gives a total of 54. This figure should then be multiplied by the relevant beta weight (1.4) and the product added to the constant term (42.6); so for this client, predicted FSIQ = $42.6 + (1.4 \times 54) = 118$ (rounded). When reporting these IQs it would be good practice to accompany them with their 90 or 95 per cent confidence intervals.

Although the above procedure is not time-consuming, it would be simpler if tables converting the sum of age-graded scaled scores to IQs could be consulted (this would also reduce the likelihood of clerical error). Such tables, for use with the present authors' four- and six-subtest short-forms, are presented in Appendices 1 and 2 respectively. The figures in the left of the columns are the sum of age-graded scaled scores and the figures on the right the predicted IQs. Space constraints do not permit the presentation of conversion tables for all the short-forms. However, these have been constructed and are available from the first author. As the regression equations presented here were built on a relatively large and representative UK sample, one can be fairly confident of their stability. However, a cross-validation study in another healthy UK sample would be valuable as would studies of clinical populations.

Finally, the treatment and discussion of the data in this study is based on classical test theory. However, as was pointed out by an anonymous referee, an alternative model is provided by generalizability theory. Although largely because of its complexity, this approach has not been widely employed (Rust & Golombok, 1989), the interested reader may wish to refer to the standard text in this area (Cronbach, Gleser, Nanda & Rajaratan, 1972).

It is also appropriate to draw the reader's attention to an assumption of the present method of constructing short-forms. The method necessarily involved administering the full-length WAIS-R (in which the standard order of subtest administration was employed). Using a subset of the 11 subtests to predict full-length IQ involves the assumption that scores on these subtests, when they are embedded amongst the other subtests would not differ appreciably from the scores that would be obtained when they were administered on their own (as would be the case when using the short-forms in practice). Although the empirical evidence on this is sparse, what evidence

there is suggests that such an assumption is justified (see Lezak, 1983, for a brief review).

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Appendix 1

Conversion table of sum of age-graded scaled scores to IQs for present authors' four-subtest short-form (Verbal = Comprehension & Similarities; Performance = B. Design & O. Assembly).

VIQ		PIQ		FSIQ			
0	54	0	52	2	46	39	101
1	56	1	55	3	47	40	103
2	59	2	57	4	49	41	104
3	61	3	60	5	50	42	106
4	63	4	62	6	52	43	107
5	66	5	64	7	53	44	109
6	68	6	67	8	55	45	110
7	71	7	69	9	56	46	112
8	73	8	72	10	58	47	113
9	75	9	74	11	59	48	115
10	78	10	76	12	61	49	116
11	80	11	79	13	62	50	118
12	83	12	81	14	64	51	119
13	85	13	84	15	65	52	121
14	87	14	86	16	67	53	122
15	90	15	88	17	68	54	124
16	92	16	91	18	70	55	125
17	95	17	93	19	71	56	127
18	97	18	96	20	73	57	128
19	99	19	98	21	74	58	130
20	102	20	100	22	76	59	131
21	104	21	103	23	77	60	133
22	107	22	105	24	79	61	134
23	109	23	108	25	80	62	136
24	111	24	110	26	82	63	137
25	114	25	112	27	83	64	139
26	116	26	115	28	85	65	140
27	119	27	117	29	86	66	142
28	121	28	120	30	88	67	143
29	123	29	122	31	89	68	145
30	126	30	124	32	91	69	146
31	128	31	127	33	92	70	148
32	131	32	129	34	94	71	149
33	133	33	132	35	95	72	151
34	135	34	134	36	97		
35	138	35	136	37	98		
36	140	36	139	38	100		

Appendix 2

Conversion table of sum of age-graded scaled scores to IQs for present authors' six-subtest short-form (Verbal = Comprehension, Similarities & Arithmetic; Performance = B. Design, O. Assembly & P. Arrangement).

VIQ		PIQ		FSIQ			
1	46	2	46	9	45	66	108
2	47	3	48	10	46	67	109
3	49	4	50	11	47	68	110
4	51	5	52	12	48	69	111
5	53	6	54	13	49	70	112
6	55	7	56	14	51	71	113
7	59	9	59	15	53	73	115
8	59	9	59	16	53	73	115
9	61	10	61	17	54	74	117
10	63	11	63	18	55	75	118
11	65	12	65	19	56	76	119
12	66	13	67	20	57	77	120
13	68	14	69	21	58	78	121
14	70	15	71	22	59	79	122
15	72	16	73	23	60	80	123
16	74	17	75	24	62	81	124
17	76	18	76	25	63	82	125
18	78	19	78	26	64	83	126
19	80	20	80	27	65	84	128
20	82	21	82	28	66	85	129
21	84	22	84	29	67	86	130
22	85	23	86	30	68	87	131
23	87	24	88	31	69	88	132
24	89	25	90	32	70	89	133
25	91	26	92	33	71	90	134
26	93	27	94	34	73	91	135
27	95	28	95	35	74	92	136
28	97	29	97	36	75	93	137
29	99	30	99	37	76	94	139
30	101	31	101	38	77	95	140
31	103	32	103	39	78	96	141
32	104	33	105	40	79	97	142
33	106	34	107	41	80	98	143
34	108	35	109	42	81	99	144
35	110	36	111	43	82	100	145
36	112	37	113	44	84	101	146
37	114	38	114	45	85	102	147
38	116	39	116	46	86	103	148
39	118	40	118	47	87	104	150
40	120	41	120	48	88	105	151
41	122	42	122	49	89	106	152
42	123	43	124	50	90	107	153

Appendix 2 (*cont.*)

Conversion table of sum of age-graded scaled scores to IQs for present authors' six-subtest short-form (Verbal = Comprehension, Similarities & Arithmetic; Performance = B. Design, O. Assembly & P. Arrangement).

	VIQ		PIQ			FSIQ	
43	125	44	126	51	91	108	154
44	127	45	128	52	92	109	155
45	129	46	130	53	93	110	156
46	131	47	132	54	95	111	157
47	133	48	133	55	96	112	158
48	135	49	135	56	97	113	159
49	137	50	137	57	98	114	161
50	139	51	139	58	99		
51	141	52	141	59	100		
52	142	53	143	60	101		
53	144	54	145	61	102		
54	146	55	147	62	103		
55	148	56	149	63	104		
56	150	57	151	64	106		
57	152			65	107		