OBTAINING FACTOR SCORES ON THE WECHSLER ADULT INTELLIGENCE SCALE

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PROBLEM

ELSEWHERE (3) it has been argued that, when reporting a subject's results on the WISC (5), it is preferable to give them in the form of scores or intelligence quotients on orthogonal factors than as Verbal and Performance I.Q.s since the latter overlap in a rather arbitrary fashion. In this study a similar recommendation is implied when dealing with a subject's results on the WAIS (6) and the problem is to indicate how factor scores on this test can be obtained.

PROCEDURE

A factor analysis of the correlation matrix for the (18–19) year group (6), omitting the *Information* subtest which is seldom administered at this Institute, was performed using the Lawley Maximum Likelihood Method of analysis (4). After two factors had been fitted the residuals were tested and found not to be significant ($\chi^2=24\cdot9$; d.f.$=26$). The factors were then rotated so that the first passed through the Vocabulary subtest. This rotation is the one most acceptable to my clinical colleagues, who then label the factor "verbal-intellectual, (vg)". The second factor, orthogonal to it, is labelled "space-performance (sp)". The unrotated and the rotated loadings are given in Table I.

TABLE I

Factor Loadings for (18–19) Age Groups

	Unrotated			Rotated	
	I	II	h^2	I	II
1. Comprehension ..	·746	−·217	·604	·777	·011
2. Arithmetic	·715	−·114	·524	·717	·100
3. Similarities	·834	−·169	·724	·847	·082
4. Digit span	·637	−·163	·432	·657	·030
5. Vocabulary	·874	−·268	·836	·914	·000
6. Digit symbol ..	·697	−·066	·490	·686	·141
7. Picture completion ..	·773	·231	·651	·672	·447
8. Block design ..	·727	·391	·726	·609	·596
9. Picture arrangement	·697	·207	·529	·606	·402
10. Object assembly ..	·690	·431	·661	·533	·614
Per cent. variance ..	55·51	6·26	61·77	50·47	11·30

All subtests, Verbal and Performance alike, are seen to have high loadings on the first rotated factor, while the Verbal subtests together with the Digit Symbol subtests have negligible loadings on the second factor.

The correlation matrices for the (25–34) and the (45–54) age groups were now considered. Here the hypothesis was set up that two factors would be sufficient to account for the covariance of the tests and that the pattern of loadings would be similar to that of the rotated loadings for the (18–19) age

https://doi.org/10.1192/bjp.106.444.1060 Published online by Cambridge University Press

group. In other words it was postulated that the first six tests would have zero loadings on the "space-performance" factor. This hypothesis was tested by a new maximum likelihood method of analysis described by Lawley (1) and discovered independently by Howe, and by others (2). The great advantage of this new method is that the estimated loadings do not require rotation.

The results of the analyses are given in Table II. The residual matrices after two factors have been fitted were not tested for significance as the test involves laborious calculations (a programme for doing it on an electronic computer is in hand). When the loadings in Table II are compared with the rotated loadings in Table I it is seen that for all three age groups the pattern is closely similar. In each case all subtests have high loadings on the "verbal-intellectual" factor, Vocabulary, Similarities and Comprehension topping the list. For the "space-performance" factor the highest loadings for each age group are for Object Assembly and Block Design. The Verbal tests in every case have loadings on this second factor which are virtually zero while the loadings for the Digit Symbol subtest are negligible.

TABLE II

Factor Loadings for (25–34) and (45–54) Age Groups

Test	(25–34) Years			(45–54) Years		
	I	II	h^2	I	II	h^2
1. Comprehension ..	·776	·052	·605	·827	·042	·686
2. Arithmetic	·657	·147	·453	·755	·177	·601
3. Similarities	·804	·018	·647	·796	·073	·639
4. Digit span	·569	·086	·331	·609	·173	·401
5. Vocabulary	·921	−·042	·850	·910	−·017	·828
6. Digit symbol ..	·641	·170	·440	·690	·191	·513
7. Picture completion ..	·677	·364	·591	·726	·327	·634
8. Block design ..	·606	·551	·671	·586	·556	·653
9. Picture arrangement	·684	·311	·565	·708	·232	·555
10. Object assembly ..	·487	·577	·570	·567	·533	·606
Per cent. variance ..	47·94	9·29	57·23	52·56	8·59	61·16

REGRESSION WEIGHTS FOR FACTOR SCORES

In virtue of the similarities between the factor patterns for the three age groups it was decided to average the three correlation matrices (using the z-transformation) and to average the three sets of factor loadings and find one set of regression weights (4) for estimating scores on the two factors. These are given in Table III, the values in brackets falling below the 5 per cent. level of significance. Below the true weights approximate weights (to simplify the calculations) are indicated. Below them again the scaled scores for a hypothetical subject are given. These scores are expressed in standardized form by subtracting 10 from each and by dividing the remainder by 3, the standard deviation of the scaled scores.

Examination of the regression weights, Table III, shows that by far the

TABLE III

Regression Weights for Estimating Factor Scores

Tests	1	2	3	4	5	6	7	8	9	10
Factor "vg"	·16	·09	·19	·08	·44	·08	·06	(·00)	·04	(·00)
Factor "sp"	−·16	(−·02)	−·13	−·04	−·48	(·01)	·22	·49	·15	·42
Approximate Weights										
Factor "vg"	·2	·1	·2	·1	·4	·1	·1	0	0	0
Factor "sp"	−·2	0	−·1	0	−·5	0	·2	·5	·2	·4
Subject's Scores										
Scaled score	13	12	10	7	16	16	8	13	10	14
St. score	1	0·7	0	−7	2	2	−0·7	1	0	1·3

https://doi.org/10.1192/bjp.106.444.1060 Published online by Cambridge University Press

most important subtest for estimating the "vg" factor score is Vocabulary; it is followed by Similarities and Comprehension. For estimating the "sp" factor Block Design and Object Assembly have relatively high positive weights, but to counteract the high "vg" content of these tests a high negative weight for Vocabulary is required. (Digressing for a moment it is seen that should a shortened form of the WAIS be required the regression weights indicate the subtests which should be retained.)

To illustrate how factor scores are calculated we will use the standardized scores given in the last row of Table III. These scores are multiplied in turn by the corresponding regression weights, rows one and two (or rows three and four) of the table, and the results are added. In this way the "vg" factor score is found to be 1·181 and the "sp" factor score to be −0·192. The variances of the factor scores can also be found (4), and for the regression weights given never have to be recalculated. For the factors in question they are 0·92 and 0·65, and as the covariance between the factor scores is 0·0787 the correlation between estimated factor scores is 0·10. To express the factor scores as I.Q.s they are restandardized. They then become $1 \cdot 181/\sqrt{0 \cdot 92}$ and $-0 \cdot 192/\sqrt{0 \cdot 65}$, namely 1·229 and −0·239 for the "vg" and "sp" factors respectively. Expressed as I.Q.s these are $100+15\times 1 \cdot 229=118 \cdot 4$ and $100-15\times 0 \cdot 239=96 \cdot 4$. These differ by 22 points of I.Q. Had the scaled scores been expressed as Verbal and Performance I.Q.s in the ordinary way, assuming the subject to be in the 18–19 age range, the values 101 and 115 respectively would have been obtained. These I.Q.s are almost the reverse of those obtained when the factor scores are used and could be misleading should the labels Verbal and Performance be taken literally. The discrepancy between the results obtained from factor scores and conventional usage is caused largely by including the subtest Digit Symbol amongst the Performance tests: the factor analysis and regression weights strongly indicate that it does not belong there.

Summary and Discussion

Factor analyses of the correlation matrices given in the WAIS manual are reported and sets of regression weights are given for estimating "verbal-intellectual", and "space-performance" factor scores. The variances and the covariance of the estimated scores are given and it is demonstrated how to convert a S's scaled scores on the test into factor score I.Q.s. It is argued that the latter are preferable to the conventional Verbal and Performance I.Q.s for use in clinical work.

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https://doi.org/10.1192/bjp.106.444.1060 Published online by Cambridge University Press