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The Wechsler Adult Intelligence Scale—Revised (WAIS-R): factor structure in a U.K. sample

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Summary—The factor structure of the WAIS-R was examined in a U.K. sample free of neurological, psychiatric or sensory disorder *(n* = 120). Principal components analysis was performed with varimax rotation. Extraction of 2 and 3 factor solutions were specified *a priori.* For comparison purposes, the same procedures were followed with the U.S.A. standardisation sample data. Encouragingly for U.K. users of the WAIS-R, coefficients of congruence and visual inspection of the factor loadings indicated that factor structure in the U.S.A. and U.K. samples was closely similar.

INTRODUCTION

In the United States, the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955) has now been superseded by the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981). The WAIS-R has retained the original WAIS format (i.e. it contains the same 11 subtests which are used to derive Full Scale, Verbal, and Performance IQs). However rules for the administration and scoring of some subtests have been changed and around 20% of item content has been updated. This latest version of the Wechsler scale was standardised on a representative sample of 1880 Americans during 1976-1980 (Wechsler, 1981). Wechsler (1981, p. 47) presents correlations between WAIS and WAIS-R subtests (obtained by testing 72 5s on both tests). Examination of these correlations reveals that five WAIS-R subtests share only around 50% or less of their variance with the corresponding WAIS subtest (25% in the case of Picture Arrangement). This suggests that these revised subtests may now be measuring different aspects of intellectual ability.

Despite these changes, however, factor analytic studies of the WAIS-R standardisation sample have demonstrated that the factor structure of the WAIS-R closely resembles that of the WAIS (see Leckliter, Matarazzo and Silverstein, 1986, for a detailed review). A variety of methods of factor extraction and rotation have been employed (e.g. see Blaha and Wallbrown, 1982; O'Grady, 1983; Gutkin, Reynolds and Galvin, 1984; Canavan, Dunn and McMillan, 1986). The most common approach, however, has been to use principal factoring as the method of extraction with varimax rotation to an orthogonal solution (i.e. Silverstein, 1982; Parker, 1983; Gutkin *et al,* 1984; Beck, Horwitz, Seidenberg, Parker and Frank, 1985). Both 2- and 3-factor solutions have been reported, reflecting a continuation of the debate over which of these two solutions were most appropriate for the WAIS (Matarazzo, 1972). In studies reporting two factor solutions (Silverstein, 1982; Parker, 1983; Gutkin *et aL,* 1984), the Vocabulary, Information, Comprehension and Similarities subtests have loaded highly on the first factor, which thus corresponds to the WAIS *verbal* factor. Block Design and Object Assembly load highly on the second factor (with other Performance Scale subtests exhibiting more modest loadings), which thus corresponds to the WAIS *perceptual organisation* factor. In three factor solutions (Parker, 1983; Beck *et ai,* 1985) the same two factors emerge, while Arithmetic and Digit span load on the third factor which corresponds to the WAIS *freedom from distractability* factor.

In the U.K., Wechsler's scales have been the most commonly used IQ measures in both clinical and academic settings. Now that the UK version of the WAIS-R is available (Lea, 1986), it is to be expected that this scale will enjoy the same popularity. However, as was the case for all of Wechsler's previous scales, a U.K. standardisation sample has not been collected. Clearly then, extensive research is required to examine the psychometric properties of the WAIS-R in U.K. 5s. In the present authors[1] view, this research effort should initially be aimed at establishing baseline information on the general adult population before turning to an examination of clinical populations.

The aim of the present study is to examine the factor structure of the WAIS-R in a U.K. sample and compare it with the factor structure in the U.S.A. standardisation sample. Two- and 3-factor solutions will be examined. Extraction will be carried out with principal components analysis. Thus it will be possible to conduct a further check on the robustness of the WAIS-R's factor structure by comparing the present standardisation sample results with the factor structure obtained by the principal factoring method (e.g. Silverstein, 1982).

METHOD

Subjects

The sample consisted of 120 5s (61 males, 59 females) who were free of neurological, psychiatric or sensory disability. *Ss* were recruited from a wide variety of sources e.g. local and national companies, non-medical health service personnel, community centres and members of local clubs (pensioners clubs, angling clubs, etc). Most received a small honorarium for their participation. Mean years of education was 11.8 yrs (2.8) with a range of 7-20 yrs. Mean age of the sample was 40.6 yrs (18.0) with an age range of 16-83 yrs. Three arbitrary age bands were formed (16-35, 36-55, 56-83) and the proportions of the sample falling into each band were compared with the general population (using figures from the 1981

Table 1. First principal component (FPC) and varimax rotated factor structure of the WAIS-R in the U.S. standardisation sample (factor loadings for 2-factor solution shown in parentheses)

	FPC	Varimax rotation* Factor I	Factor II	Factor III
Information	0.82	**0.81** (0.84)	0.21 (0.25)	0.29
Digit Span	0.65	0.27 **(0.59)**	0.11 (0.30)	**0.83**
Vocabulary	0.86	**0.82 (0.87)**	0.22 (0.27)	0.34
Arithmetic	0.78	0.49 **(0.67)**	0.28 (0.40)	**0.59**
Comprehension	0.80	**0.79 (0.81)**	0.23 (0.26)	0.26
Similarities	0.81	**0.75 (0.76)**	0.30 (0.34)	0.25
P. Completion	0.73	0.48 (0.43)	**0.64 (0.64)**	0.11
P. Arrangement	0.68	**0.51** (0.48)	0.49 (0.49)	0.13
Block Design	0.74	0.26 (0.33)	**0.72 (0.79)**	0.38
Object Assembly	0.64	0.14 (0.14)	**0.85 (0.86)**	0.19
Digit Symbol	0.64	0.23 (0.43)	0.37 **(0.50)**	**0.61**
Variance (%)	55.3	31.7 38.2	21.4 25.8	17.7

*Loadings >0.50 highlighted.

census). A goodness of fit χ^2 test revealed that the sample did not differ significantly from the census figures ($\chi^2 = 2.41$, d.f. = 2, NS). Social class was determined by the OPCS Classification of Occupations (1980). The social class distribution of the sample was as follows: social class 1 = 8.3%, 2 = 22.5%, 3 = 45.8%, 4 = 15.8%, 5 = 5.8%. A goodness of fit χ^2 test revealed that this distribution did not differ significantly from the social class distribution of the general U.K. population ($\chi^2 = 1.14$, d.f. =4, NS).

Procedure

The WAIS-R was administered and scored according to standardised procedures (Wechsler, 1981; Lea, 1986). A principal components analysis (PCA) was performed on the scaled scores of the 11 WAIS-R subtests with the extraction of 2 factors specified *a priori.* A second PCA was performed to extract 3 factors. In both cases the factors extracted by PCA were rotated to an orthogonal solution using varimax. For comparison purposes the same procedure was carried out with the subtest intercorrelations obtained in the standardisation sample (Wechsler, 1981, p. 46).

RESULTS

Full Scale WAIS-R IQ in the U.K. sample ranged between 71 and 140 with a mean of 100.6 (13.5).

The subtest loadings on the first unrotated factor extracted by PCA are presented in the left hand column of Table 1 for the U.S.A. standardisation sample and in the left hand column of Table 2 for the U.K. sample. In line with previous factor analytic studies, it can be seen that in the U.S.A. sample all subtests load highly on this factor and that it accounts for a substantial proportion of subtest variance (55.3%). Essentially the same,results were obtained in the U.K. sample with the unrotated first factor accounting for 52.9% of subtest variance.

The 2- and 3-factor solutions obtained after varimax rotation are also presented in Tables 1 and 2 for the U.S.A. and U.K. samples respectively.

Rotated factor structure in the standardisation sample

Examination of the 2-factor solution in the U.S.A. sample shows that the two rotated factors are readily identifiable with the *verbal* and *perceptual organisation* factors obtained in previous factor analytic studies of both the WAIS-R and WAIS. The Vocabulary, Information, Comprehension and Similarities, subtests load very highly on the *verbal* factor. The *perceptual organisation* factor is largely defined by high loadings from the Block Design and Object Assembly subtests, although other Performance Scale subtests have moderate loadings on this factor. The rotated 3-factor solution obtained in the U.S.A. sample is also reasonably consistent with previous WAIS-R and WAIS studies. The first two factors in the 3-factor solution are essentially the same as those obtained with a 2-factor solution. Digit Span and Arithmetic, which had only modest loadings on the *verbal* factor in the 2-factor solutions, has even lower loadings on this factor in the 3-fartor solution. These two subtests load on the third factor *freedom from distractability.*

Table 2. First principal component (FPC) and varimax rotated factor structure of the WAIS-R in the U.K. sample (factor loadings for 2-factor solution shown in parentheses)

	FPC	Varimax rotation* Factor I	Factor II	Factor III
Information	0.78	**0.87 (0.86)**	0.18 (0.14)	0.16
Digit Span	0.65	0.25 **(0.55)**	0.17 (0.35)	**0.86**
Vocabulary	0.77	**0.88 (0.90)**	0.11 (0.09)	0.21
Arithmetic	0.74	0.40 **(0.61)**	0.30 (0.41)	**0.64**
Comprehension	0.78	**0.82 (0.85)**	0.18 (0.17)	0.25
Similarities	0.84	**0.65 (0.77)**	0.32 (0.37)	0.47
P. Completion	0.75	0.48 (0.48)	**0.64 (0.61)**	0.10
P. Arrangement	0.79	**0.53 (0.59)**	**0.52 (0.53)**	0.28
Block Design	0.71	0.22 (0.27)	**0.82 (0.83)**	0.21
Object Assembly	0.62	0.20 (0.19)	**0.80 (0.77)**	0.05
Digit Symbol	0.53	0.04 (0.07)	**0.73 (0.79)**	0.32
Variance (%)	52.9	31.5 38.4	25.8 27.7	15.7

*Loadings >0.50 highlighted.

Table 3. Coefficients of congruence between rotated factors in the U.S. standardisation sample and a U.K. sample

	Factor I	Factor II	Factor III
3-factor solution	0.99	0.97	0.94
2-factor solution	0.98	0.97	—

The only noteworthy difference between the presently obtained factor structure in the U.S.A. standardisation sample (using PCA) and the previously reviewed WAIS-R studies (which used principal factoring) was in the Digit Symbol subtest's loading on Factor III in the three factor solution. It can be seen from Table 1 that Digit Symbol loads on Factor III (0.61) when PCA is the method of extraction (this loading being as high as that of Arithmetic). In contrast, in the two previous studies of 3-factor solutions (using principal factoring), Digit Symbols' loading did not exceed 0.40 (Parker, 1983; Beck *et al*., 1985).

Rotated factor structure in the U.K. sample

A comparison of the rotated factor solutions in the U.K. sample with the results obtained in the U.S.A. standardisation sample reveals a high degree of similarity. Factor I in both the 2- and 3-factor solutions (see Table 2) is readily identifiable with the *verbal* factor. Vocabulary, Information, Comprehension and Similarities all load highly on this factor (and in the same rank order as the standardisation sample). Factor II in both the 2- and 3-factor solution can be identified with the *perceptual organisation* factor. Verbal Sale subtests have low loadings, whereas Block Design and Object Assembly load highly. Other Performance Scale subtests have moderate loadings. The exception, however, is Digit Symbol which loads highly on *perceptual organisation* particularly in the 2-factor solution.

It can be seen from Table 2 that, as was the case in the U.S.A. sample. Digit Span and Arithmetic load highly on Factor III in the U.K. sample. Again, however, a difference between the two samples can be observed in the loading of Digit Symbol. In the U.K. sample, Digit Symbol has a negligible loading; whereas in the U.S.A. sample the loading is, as noted, 0.'6I.

There is no entirely satisfactory quantitative method of assessing the degree of factor structure similarity across samples. However, the coefficient of congruence proposed by Wrigley and Neuhaus (1955) would appear to be the most commonly recommended technique (e.g. see Harman, 1976; Levine, 1977). Coefficients of congruence were calculated between the rotated factors in the standardisation sample and the U.K. sample. As noted, visual inspection of the factor loadings indicated a high degree of factorial similarity between samples. It can be seen that the high coefficients of congruence (presented in Table 3) are consistent with this.

DISCUSSION

The first unrotated factor extracted by PCA represents the variance common to all subtests and has been termed general intelligence, or *g*. In both the U.S.A. and U.K. samples, all subtests load highly on this factor, which accounts for a very substantial proportion of the total subtest variance (55.3 and 52.9% respectively). As Savage (1970) has noted, Wechsler's intention in developing his scales was that individual subtests should constitute different measures of intelligence rather than be measures of different kinds of intelligence. The above results indicate that he has largely succeeded in this.

The close similarity between the rotated factor solutions in the U.S.A. and U.K. samples indicates that the WAIS-R has a very robust factor structure. This is an encouraging result for U.K. users of the test. Indeed, it is noteworthy that the (minimal) divergence between the U.S.A. and U.K. factor structure was no greater than the (again minimal) divergence between the present PCA solution in the U.S.A. sample and previous principal factoring solutions. The only clear difference between the U.S.A. and U.K. samples was in the loadings of Digit Symbol. That this difference should emerge is perhaps not surprising as (1) in the U.S.A. sample the loadings for this subtest obtained by PCA were inconsistent with principal factoring solutions, (2) variability in Digit Symbol's loadings is also evident across age bands in the U.S.A. sample (Parker, 1983), and (3) Digit Symbol has a higher proportion of specific (and by implication non-intellective) variance than any other subtest (Silverstein, 1982; Parker, 1983).

Previous studies of the WAIS-R have, as noted, indicated that its factor structure is very similar to its predecessor, the WAIS. However, a difference does emerge when the loadings of Picture Arrangement are examined. In the WAIS, Picture Arrangement loads principally on *perceptual organisation.* However, on the WAIS-R it would appear to load equally on this factor and the *verbal* factor. In the present study this was evident in both the U.S.A. and U.K. samples. This indicates that modifications to the subtest (which it will be remembered led to it having the least shared variance of all 11 WAIS/WAIS-R subtests) have increased the importance of verbal mediation in task performance.

Finally, the present results indicate that the allocation of WAIS-R subtests to Verbal and Performance Scales (within which each subtest is given equal weight in calculating the IQ score) does not have a sound factorial basis. Of the six Verbal Scale Subtests, two (Arithmetic and Digit Span) do not load very highly on the *verbal* factor even in the 2-factor solutions. In the light of the preceding discussion of Digit Symbol and Picture Arrangement, it can be seen that the construct validity of the Performance Scale is even more questionable. Dissatisfaction with the construct validity of WAIS Verbal and Performance IQ prompted a number of authors to argue that Wechsler's (1955) scoring procedures should be abandoned in favour of using factor scores to derive IQs that correspond to previously identified WAIS factors (e.g. Maxwell, 1960; Lutey, 1977). Such methods have been fruitfully applied to a number of research problems, e.g. discriminating between left and right hemisphere brain injury (Powell, 1979; Lawson and Inglis, 1983) and discriminating patients with Huntington's disease from their at risk offspring (Josiassen, Curry, Roemar, De Bease and Mancall, 1982). A number of factor score methods derived from the standardisation data are now available for the WAIS-R (e.g. Lawson, Inglis and Stroud, 1983; Gutkin *et aL,* 1984; Canavan *et ai,* 1986). The close similarity between the U.S.A. and U.K. factor structure in the present study indicates that these methods can be validly used in research and clinical practice in the U.K.

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