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NOTES AND SHORTER COMMUNICATIONS

Estimation of premorbid intelligence: combining psychometric and demographic approaches improves predictive accuracy

J. R. CRAWFORD[1]*, L. E. STEWART[2], D. M. PARKER[1], J. A. O. BESSON[2] and R. H. B. COCHRANE[2]
[1] *Departments of Psychology and ~Mental Health, University of Aberdeen, Aberdeen, Scotland*

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Summary—Regression equations have been developed to estimate premorbid WAIS IQ from (a) psychometric tests which are relatively resistant to the effects of cerebral dysfunction, and (b) demographic variables (e.g. education, occupation). The purpose of the present study was to determine whether regression equations based on the *combination* of psychometric and demographic variables would account for more WAIS IQ variance than either of the two methods alone. Normal subjects *(n* = 151) were administered the WAIS and the National Adult Reading Test and had their demographic details recorded (age, sex, education, and occupation). Equations incorporating the NART and demographic variables accounted for 73, 78, and 39% of the variance in Full Scale, Verbal, and Performance IQ. The corresponding figures for equations derived from the NART alone or demographics alone were 66, 72 and 33%, and 50, 50, and 30% respectively.

INTRODUCTION

Whether for research, clinical or medico-legal purposes, attempts to detect and quantify intellectual impairment require an estimate of premorbid intelligence since previous psychometric test results are rarely available.

One approach to the estimation of premorbid IQ is to use psychometric tests which meet the following two criteria: (1) the correlate highly with IQ (in a normal population) and (2) they are resistant to the effects of cerebral dysfunction. The most commonly used tests have been the 'Hold' subtests of the Wechsler Adult Intelligence Scale (Wechsler, 1955) and in particular the Vocabulary subtest (see Lezak, 1983). However, although these tests clearly meet the first criterion, there is considerable evidence that a decline in performance occurs with neurological disease (e.g. Vogt and Heaton, 1977; Crawford, Parker and Besson, 1988). More encouraging results have been obtained with the National Adult Reading Test (NART) (Nelson, 1982). This test consists of 50 words which 5s have to read and pronounce. As the words are predominantly short and of irregular pronunciation (e.g. deny, gauche), it has been argued that successful performance rests more on previous familiarity than current cognitive capacity. Nelson (1982) presented a regression equation based on NART performance which predicted 55% of the variance in WAIS IQ.t Combined factor analysis of the WAIS and NART (Crawford, Stewart, Cochrane, Parker and Besson, 1989) has revealed that the NART has a very high loading (0.85) on factor 1 extracted by principal components analysis (generally regarded as representing 'general intelligence') indicating that the NART has high construct validity.

With regard to the second criterion (resistance to cerebral dysfunction) predominantly encouraging results have been obtained with the NART (Crawford, 1989). Nelson and O'Connell (1978) reported that the NART performance of a group of patients with cortical atrophy did not differ significantly from matched controls, despite severe impairment on the WAIS. O'Carroll. Baikie and Whittick (1987) found that there was no decline in NART performance over a period of one year in a group of patients which dementia despite an increase in the seventy of dementia and physical disability over the same period. Crawford *et al.* (1988) have reported that the NART performance of groups of patients with Alzheimer's disease, muln-infarct dementia, alcoholic dementia and closed head injury did not differ significantly from matched control groups, uhile Crawford, Besson, Parker, Sutherland and Keen (1987) obtained the same results in a group of depressed patients.

Another approach to the estimation of premorbid IQ is to use regression equations to predict WAIS IQ from demographic variables (e.g. education, occupation, etc). This approach takes advantage of the well established relationship between such variables and IQ (e.g. Matarazzo, 1972) and attempts to find the combination which maximises the accuracy of prediction. Wilson. Rosenbaum, Broun. Rourke, Whitman and Griseil (1978), used the U.S. WAIS standardisation sample to build a demographic regression equation which predicted 53% of WAIS IQ variance. Subsequent cross-validation studies have confirmed that Wilson *et* a/.'s (1978) equation is a useful predictor of IQ (e.g. Karzmak, Heaton, Grant and Matthews, 1985; Goldstein, Gary and Levin, 1986). Since the publication of Wilson *et* a/.'s (1978) study their demographic equation has been used for a large number of research purposes—e.g. as a variable in the prediction of outcome from closed head

*To whom all correspondence should be addressed.
tThis figure was not reported in the test manual (Nelson, 1982) but can be determined from the SDs of the NART (SD_N) and WAIS (SD_W) for the standardisation sample and the corresponding *fi* weight *(B)* in the NART regression equation bv the formula:

$$\%\ \text{variance} = B\frac{SD_N}{SD_W}100$$

Table I. Results of stepwise multiple regression of WAIS scales on the NART and demographic variables

	Multiple R	R^2	Sig. R^{2} change*	
Step 1. NART	0.81	0.66	$P < 0.0001$	
Step 2. Sex	0.83	0.69	$P < 0.001$	FSIQ
Step 3. Class	0.84	0.71		
Step 4. Age	0.85	0.73	$P < 0.001$	
Step 1. NART	0.85	0.72	$P< 0.0001$	
Step 2. Sex	0.87	0.75	$P< 0.001$ P	VIQ
Step 3. Class	0.87	0.76	< 0.01	
Step 4. Age	0.88	0.78	$P < 0.01$	
Step 1. NART	0.57	0.33	$P < 0.0001$	
Step 2. Class	0.59	0.35	$P < 0.05$	PIO
Step 3. Sex	0.61	0.38	$P < 0.05$	• »v
Step 4. Age	0.62	0.39	$P < 0.05$	

'Significance of /?* chance tested by applying F test to the change in the residual sums of squares at each step.

injury (Williams, Gomes, Drudge and Kessler, 1984) and as a means of establishing the comparability of clinical groups with dementia (Bayles and Tomoeda, 1983; Weingartner, 1983). A demographic regression equation has also been built to predict WAIS IQ in a U.K. population (Crawford *et* a/., 1987).

Predictive accuracy is a crucially important determinant of the utility of regression based methods of estimating IQ. If a regression equation has high predictive accuracy then marked discrepancies in favour of predicted over obtained IQ will be less likely to occur in the normal population. Thus finer discrimination between impaired and normal intellectual functioning can be achieved. The purpose of the present study was to determine whether combining psychometric (i.e. the NART) and demographic approaches would produce regression equations which had higher predictive accuracy than equations based on either method alone. As would be expected, there is considerable covariance between the NART and demographic variables such as education (e.g. see Crawford, Stewart, Garthwaite, Parker and Besson, 1988). Clearly then, combining these variables will not have an *additive* effect on the proportion of IQ variance predicted. However, it was hypothesised that a *cumulative* effect would be observed in that (1) unshared variance in psychometric and demographic variables may still relate to IQ, and (2) demographic variables may mediate the relationship between NART performance and IQ.

METHOD

Subjects were recruited from a wide variety of sources i.e. non-medical health service employees, university employees, employees of local and national companies, the fire service, members of local clubs (e.g. pensioners clubs, angling clubs), and community centres. The majority were paid a small honorarium. The final sample consisted of 151 5s (79 males and 72 females) who were free of neurological, psychiatric, and sensory disability. The age range of the sample was 16-88 with a mean of 42.0 (SD = 7.1). Mean years of education was 12.6 (SD = 3.1).

The WAIS and NART were administered and scored according to standardised procedures (Wechsler, 1955; Nelson, 1982). The demographic details of 5s were recorded (age, sex, years of education, and occupation). Occupation was used to determine social class using the OPCS Classifications of Occupations (1980). Married females were coded by their husbands' occupation. The major lifetime occupation was coded for Ss who were retired. In recording years of education, 5s were credited with 0.25 of a year for every year of attendance at day-release or evening classes (provided that the evening classes were leading to a qualification), in addition to their number of years of full-time education. Sex was dummy variable coded (Cohen and Cohen, 1983) with males = 1: females = 2.

RESULTS

The means and standard deviations for WAIS Full Scale IQ (FSIQ), Verbal IQ (VIQ) and Performance IQ (PIQ) were 111.8 (12.7), 112.1 (14.2) and 110.1 (11.6) respectively. The corresponding IQ ranges were 75-140, 72-143 and 73-134.

Using a stepwise procedure, WAIS FSIQ, VIQ, and PIQ were individually regressed on NART errors, age, sex, education, and social class. For all three WAIS scales, NART errors was the single best predictor of IQ (accounting for 66, 72, and 33% of the variance in FSIQ, VIQ, and PIQ respectively).

It can be seen from Table 1 that the addition of demographic variables to the equations significantly increased R^2 at each subsequent step (i.e. increased the variance predicted) for all three WAIS scales. The final equations, which accounted for 73, 78 and 39% of the variance in FSIQ, VIQ, and PIQ respectively, are presented below:

$$\text{Predicted FSIQ} = 135.96 - 0.789\ (\text{NART errors}) - 4.6\ (\text{sex}) - 2.15\ (\text{class}) + 0.112\ (\text{age})$$
$$\text{Predicted VIQ} = 139.93 - 0.954\ (\text{NART errors}) - 4.9\ (\text{sex}) - 2.04\ (\text{class}) + 0.109\ (\text{age})$$
$$\text{Predicted PIQ} = 126.01 - 0.462\ (\text{NART errors}) - 2.02\ (\text{class}) - 3.7\ (\text{sex}) + 0.108\ (\text{age})$$

To determine the predictive accuracy of demographic equations the regression procedure set out above was repeated with the NART excluded from the analysis. The combined equations predicted 7, 6, and 6% more FSIQ, VIQ, and PIQ variance than the corresponding equations derived from the NART alone and 22, 28, and 7% more variance than the corresponding demographic equations (see Table 2).

Table 2. Percentage of WAIS IQ variance accounted for by three methods of prediction

	Full scale IQ			Verbal IQ			Performance IQ		
	% variance	Multiple R	SE Est	% variance	Multiple R	SE Est	% variance	Multiple R	SE Est
NART alone	66	0.81	7.37	72	0.85	7.48	33	0.57	9.54
Demographics alone	50	0.71	9.08	50	0.71	10.17	30	0.55	9.83
Combined	73	0.85	6.66	78	0.88	6.76	39	0.62	9.18

When used in the individual case the predicted IQ derived from these equations should be compared with the actual IQ obtained on testing. A substantial discrepancy in favour of predicted IQ raises the possibility of intellectual deterioration. The probability that a particular size of discrepancy in favour of predicted IQ could occur in the normal population can be assesed by referring to Table 3. For example it can be seen from Table 3 that, in the case of FSIQ, a discrepancy in favour of predicted IQ of more than 15 IQ points occurred in only 1% of the present normal sample. Therefore a discrepancy of this magnitude would strongly suggest the presence of intellectual impairment.

DISCUSSION

The present results demonstrate that regression equations which combine psychometric (i.e. the NART) and demographic variables predict a very substantial proportion of WAIS IQ variance. As noted, the combined equations predicted substantially more IQ variance than equations derived from demographic variables alone. Although the increment in predicted variance was less marked in the case of the NART it was nevertheless highly significant. The improvement in predictive accuracy can also be illustrated by comparing the percentage of normal 5s exhibiting sizeable discrepancies between predicted IQ and the IQ obtained by testing. As recorded above, only 1% of the present sample exhibited a discrepancy of more than 15 IQ points in favour of predicted FSIQ. However, when FSIQ was predicted from either the NART or demographic variables alone, the corresponding figures were 3 and 5% respectively.

The use of these equations in research and practice is limited to a UK population because methods of coding occupation differ from country to country and because it cannot be assumed that the relationship between WAIS IQ and either demographic variables (e.g. education) or NART performance will be the same outwith the U.K. The encouraging results obtained in the present study, however, suggest that conducting a similar exercise with other populations (e.g. in the U.S.) would be a worthwhile exercise, as would the development of similar combined equations to predict WAIS-R IQ (Wechsler, 1981; Lea, 1986).

Finally, the present equations were developed to provide an estimate of *premorbid* IQ in cognitively impaired clinical groups. It is clear, however, that they have wider applications.

IQ can be a mediating factor in the relationships between many diverse psychological variables (e.g. see Matarazzo, 1972). A good case can therefore be made for the inclusion of an IQ measure in almost all psychological research. Practical constraints, however, normally preclude the use of lengthy tests such as the WAIS. The present equations predict a very substantial proportion of WAIS IQ variance in the normal population and the information required can be rapidly collected. They should therefore prove to be a useful and convenient research tool.

Table 3. Distribution of positive predicted—obtained IQ discrepancies in normal subjects*

Predicted minus obtained discrepancy	% of *S*s when FSIQ is predicted	% of *S*s when VIQ is predicted	% of *S*s when PIQ is predicted
1	47	49	46
2	44	45	42
3	36	36	38
4	30	32	33
5	24	30	29
6	17	24	26
7	15	16	25
8	13	10	23
9	11	9	17
10	7	5	15
11	6	4	11
12	4	3	10
13	3	1	8
14	2	1	7
15	2	1	6
16	1	1	3
17	1	1	3
18	1	1	3
19	1	0	3
20	0	0	2
21	0	0	2
22	0	0	1
23	0	0	1
24	0	0	1
25	0	0	1
26	0	0	1
27	0	0	1
28	0	0	1
29	0	0	1
30	0	0	0

*The figures opposite the discrepancy scores represent the percentage of normal *S*s who exhibited that size of positive discrepancy *or larger*. For example, in the case of FSIQ, 1% of *S*s exhibited a discrepancy of 10 IQ points and a further 6% of *S*s exhibited a discrepancy greater than 10. Therefore the percentage opposite a discrepancy of 10 is 7%.

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