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ABSTRACT

This report discusses the relationship between bilingualism and mental development of bilingual children. After a review of the relevant literature, a specific study is described. The linguistic background of 648 children from 29 schools, age 10 through 12 inclusive, was measured with the Welsh Linguistic Background Scale. General intelligence was assessed with three nonverbal tests: Raven's Progressive Matrices, Daniel's Figure Reasoning Test and the Non-Verbal Test No. 2 of the National Foundation for Educational Research. Objectives were to: (1) determine which of the nonverbal tests was the most independent of linguistic background and hence most suitable for intelligence testing in mixed language areas, and (2) describe the relationship between linguistic background and test scores. Conclusions are that: (1) none of the tests used is completely suitable for evaluating Welsh-speaking children if the results are to be compared with those of English-speaking children; (2) Welsh-dominant bilingual children scored consistently lower than English-dominant children; (3) a correlation exists between test performance and degree of bilingualism; (4) the location of a community accentuates the influence of bilingualism; (5) occupational levels and socioeconomic status must be considered when interpreting test scores; and (6) Raven's Progressive Matrices is the most independent test. (CLK)

UNIVERSITY COLLEGE OF WALES
ABERYSTWYTH

FACULTY OF EDUCATION

Bilingualism and Non-Verbal Intelligence: A Study of Test Results

Pamphlet No. 4

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Bilingualism and Non-Verbal Intelligence:

a study of performance on certain non-verbal tests, compared with scores on a Welsh linguistic background scale.

by
E. R. MORGAN.

Foreword

This, the fourth pamphlet in the series published by the Collegiate Faculty of Education, is a brief account of the research carried out by Mr E. R. Morgan and embodied in a thesis for the degree of M.A. in 1955. (The thesis may be consulted, by anyone desirous of fuller details, in the National Library of Wales, Aberystwyth.)

Discussion and enquiry into various aspects of the relationship between bilingualism and "intelligence" have been going on for some thirty years: the investigation here described adds a new combination of techniques and provides a stimulus to further research in this field.

Mr Morgan attempted to discover which of three well-known non-verbal tests of intelligence is the most suitable for use in bilingual areas in Wales by reason of being least affected by differences in linguistic background. His conclusions contain a warning against undue dependence upon even the best of existing non-verbal tests for selection purposes in areas where there are significant differences in the linguistic background of the pupils tested.

The methods of enquiry, which involve the use of Miss M. E. Gwenda Rees's Linguistic Background Scale (Pamphlet No. 2 in this series), the bibliography, and the results set out in the present pamphlet will be of immediate service to teachers and educational administrators in Wales.

Amongst those concerned in the preparation of the pamphlet I wish, on behalf of the Faculty, to thank particularly Mr J. R. Morrison, under whose direction Mr Morgan's work was done; Mr D. Gareth Lewis, research assistant; and Drs H. A. Saer and J. L. Williams, successive advisory officers to the Faculty.

IDWAL JONES,
Dean of the Faculty.

July 1957.

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Introduction: the Background to the Problem

The Report (1953) of the Advisory Council for Education (Wales) accepts bilingualism as "the basic aim of Welsh education"; yet investigators in Wales and in other bilingual countries are not agreed upon the effect bilingualism has on the mental development of children. In particular there are divergent results from studies of the relationship between bilingualism and 'general intelligence.' Certain investigations have indicated an inferiority of bilinguals in tests of general intelligence, while others have revealed no such difference between different linguistic groups. A small minority of studies, not one of which was conducted in Wales, report bilinguals to be superior to monoglots in such tests.

Divergencies in the results of investigations into the "bilingual problem" are partly due to the different interpretations of the terms "bilingual" or "bilingualism." The majority of investigators in Wales have assumed that bilingualism is a homogeneous phenomenon and, therefore, that its influence upon mental development is the same for all the many degrees of language saturation it is possible to include under the broad designation "bilingual." In such investigations differentiation between linguistic groups in mixed language areas has rested upon a subjective basis; being either the investigator's personal knowledge of the language of a child or what was considered to be the language of the home, chapel, school and play. Consequently a population in a linguistically mixed area was invariably classified into two distinct linguistic groups, viz., "bilingual" and "monoglot." This distinction is unsatisfactory: between the extremes of monoglot Welsh and monoglot English there are many degrees of bilingualism which cannot justifiably be covered by the general term "bilingual." Therefore the result of any investigation which relates performance in tests to language saturation cannot be considered significant "unless the linguistic background of the children has also been measured objectively and no accurate conclusions on the bilingual problem can be drawn until the degrees of bilingualism are measured quantitatively."*

* See also references 11 and 15 in the Bibliography below.

The formulation of the Welsh Linguistic Background Scale satisfies this requirement and permits the abandonment of the unsatisfactory dichotomy between bilingual and monoglot in favour of a more refined, objective division of a linguistically mixed group which permits comparisons to be made between the sub-groups into which bilinguals may be divided.

Investigators into the problem of bilingualism have indicated the language handicap of bilingual children in verbal tests of intelligence. The overall conclusion is that for purposes of comparing individuals or groups it is apparent that tests in the vernacular must be used only with individuals having equal opportunities to acquire the vernacular of the test. This requirement precludes the use of such tests in making comparative studies of individuals brought up in homes in which two vernaculars are used, or in which the vernacular of the test is not used. The many difficulties which this requirement involves are most satisfactorily overcome by substituting "non-verbal" for verbal tests of intelligence, and standardising such tests for varying degrees of language saturation.

Review of Relevant Research

D. J. Saer and Frank Smith were the first in Wales to use tests of intelligence, performance and attainment, in attempts to discover possible differences in the mental development of monoglot and bilingual children. Saer's (1922, 1923) investigations disclosed an inferiority among rural bilinguals in these tests, such differences becoming "consistently greater in degree with each year from 7 to 11 years of age." Smith (1923) confirmed that, under the contemporary organization of schools, bilingualism appeared to be "an intellectual disadvantage." However the lack of a sufficiently objective, quantitative basis in both studies greatly weakens their conclusions.

In a more objective investigation which pioneered the use of statistical analysis in interpreting the results of bilingual research in Wales, W. R. Jones (1933) found no statistically significant difference in the performance of 57 monoglot and 62 bilingual children in a series of verbal and non-verbal tests.

E. M. Barke (1933) conducted an investigation in South Wales among 697 children, 302 of whom were classed as "monoglots," and concluded that "bilingual children will

not prove inferior to monoglots (with a similar social environment) in an approved Intelligence Test from which the linguistic element has been removed." This claim was confirmed by a later study conducted by Barke (1938) in conjunction with D. E. Parry-Williams when the performances of 54 monoglots and 47 bilinguals in an intelligence and a verbal test were compared. Likewise Cyril James (1947) found that the difference between a fairly homogeneous socio-economic group of monoglots and bilinguals of 8 to 11 years of age in non-verbal tests of intelligence was " statistically insignificant."

In the investigations to which reference has been made there are certain underlying assumptions—

(a) That a mixed language population can be divided into two separate populations, viz., " monoglot " and " bilingual."

(b) That such a division could be accomplished without an objective measure of bilingualism.

(c) That, therefore, the influence of bilingualism on mental development is the same for the many degrees of language saturation it is possible to include under the general term " bilingual."

As previously explained such assumptions are either untenable or unsatisfactory and undermine the conclusions of the investigations reviewed.

The use of an objective measure of bilingualism does not result in any common agreement regarding differences between groups of children possessing different degrees of linguistic background in performances in non-verbal tests of intelligence.

W. R. Jones and W. A. C. Stewart (1951), utilising an objective measure of bilingualism, and comparing the performances of 518 bilingual and 326 monoglot children aged 10⅓ to 11⅓ in Jenkins' Non-Verbal Test of Mental Ability, found a " highly significant difference " in favour of the monoglot group. Yet W. R. Jones (1953), utilising the same non-verbal test and the same measure of bilingualism as in the previous investigation, found no statistically significant difference between the performances of 64 monoglot and 51 bilingual children aged 10 to 12 years.

Such divergent results emphasise the need for a stricter definition of the term " bilingual." The present investigation, employing an objective, quantitative measure of Welsh Linguistic Background, attempts to equate performances in non-verbal tests with specific, objectively defined degrees of linguistic background.

The Main Investigation—its Design and Results

The varying linguistic background of 648 children* aged 10:0 to 12:0 inclusive from 29 schools in Mid and South Wales was measured with the Welsh Linguistic Background Scale†. 'General intelligence' was assessed in terms of the performance of this bilingual group in three non-verbal tests of intelligence, viz., Raven's Progressive Matrices (1938), Daniels' Figure Reasoning Test and the Non-Verbal Test No. 2 of the National Foundation for Educational Research (abbreviated for convenience to R.P.M., D.F.R., and N.V. 2).

The aims of the investigation were two-fold—

(a) The comparison of correlations between quantitative measures of Welsh Linguistic Background and scores in the three tests in an attempt to discover which of these supposedly non-verbal tests was most independent of this linguistic background and, accordingly, the most efficient test for use in linguistically mixed areas in Wales.

(b) A systematic study of the relation between degrees of Welsh Linguistic Background and scores in the three tests.

Briefly, the study sought to discover the effect which the possession and use of two dissimilar languages may have on a child's success in the solution of a series of non-verbal problems. The extent of this success was taken as a measure of the child's general intelligence which was then related to an objective measure of the "Welshness" of the child.

* Mean age 11 years 1.25 month.

† See Pamphlet No 2. A Welsh Linguistic Background Scale. Faculty of Education, U.C.W. (1954).

Design of the Experiment

The Welsh Linguistic Background Scale enables a bilingual population in Wales to be classified into strictly defined, quantitative categories of bilingualism. This in turn permits a statistical comparison of the test performances of children within each bilingual category and an examination of the effect of bilingualism on test scores.

In this investigation the range of linguistic background which, theoretically, extends from 0% to 100%, that is, from monoglot English to monoglot Welsh, was divided into 10 categories (0 - 9%, 10 - 19% etc.), in order that comparisons could be made between children of defined degress of linguistic background.

Throughout the investigation the calculation of Standard

Errors[1] and Critical ("t") Ratios[2] was undertaken in order to test for statistical significance the differences in mean test scores of the ten bilingual categories. To indicate the overall relationship between bilingualism and test scores the correlation coefficients between these variables were calculated.

The sample of children tested was essentially a random choice except for the fact that the investigation was conducted in areas in Mid and South Wales which would most readily yield a population whose linguistic background was such that each of the 10 bilingual categories would contain 50 children. As the investigation proceeded it was found that the minimum sample of 500 children did not possess the required spread of linguistic background and in an attempt to produce a linguistically balanced sample, further children were tested. To achieve the desired minima in the 80 - 89% and 90 - 99% categories would have meant the selection of specific rather than random schools and, as this would have biased the sample, it was decided to base the investigation on the results of a sample of 648 children. Furthermore, each bilingual category was not reduced to a similar size as this process would have involved a considerable depletion in the number of children available and a consequent loss of information. It would also have entailed a selection from a population which, originally, had been randomly selected and again would have biased the sample. The distribution of the Welsh Linguistic Background of the final sample is shown in Table 1.

TABLE 1

DISTRIBUTION OF THE WELSH LINGUISTIC BACKGROUND OF THE SAMPLE TESTED

Bilingual Category	Boys	Girls	Total
0 - 9%	83	58	141
10 - 19%	32	29	81
20 - 29%	25	27	52
30 - 39%	22	31	53
40 - 49%	20	21	41
50 - 59%	31	26	57
60 - 69%	32	41	73
70 - 79%	25	56	81
80 - 89%	20	26	46
90 - 99%	11	12	23
Total	301	347	648

1 See p. 93, Vernon: The Measurement of Abilities, U.L.P. (1940).

2 See p. 95, ibid.

In presenting the Welsh Linguistic Background Scale and the three tests, every precaution was taken to ensure that each child received the test instructions in the language (Welsh or English) with which he or she was most familiar. In addition, to ensure linguistic equality, the English instructions to the Scale and the tests were translated into a form of Welsh most readily understood by the Welsh-speaking children and which was as closely comparable to the English as was grammatically possible. As a check on the replies to the Scale, the bilingualism of each child was discussed with the Head or class-teacher.

The Scale and tests were presented in three separate periods on two successive days. This comparatively short period of testing together with certain similarities between the tests necessitated the presentation of the tests in a simple permutated order to ensure the limitation of a possible "practice effect" on test performances.

The Main Results of the Investigation

In the three tests, girls proved slightly superior to the boys in the majority of the bilingual categories, but the differences in mean scores was not sufficiently great to justify a separate consideration of the sexes.

The performance of the complete sample in each test is shown in Table 2.

TABLE 2

MEAN SCORES AND STANDARD DEVIATIONS WITHIN BILINGUAL CATEGORIES IN THE THREE TESTS: RAVEN'S PROGRESSIVE MATRICES, JENKINS' NON-VERBAL TEST 2, AND DANIELS' FIGURE REASONING TEST.

		R.P.M.		D.F.R		N.V. 2	
Bilingual Category	N	Mean Score	S.D.	Mean Score	S.D.	Mean Score	S.D.
0 - 9%	141	36.74	10.47	22.25	7.22	44.05	13.30
10 - 19%	81	36.69	11.89	22.75	7.85	46.21	11.54
20 - 29%	52	38.90	9.88	22.85	6.48	46.44	12.19
30 - 39%	53	37.92	11.01	22.75	7.29	45.32	13.44
40 - 49%	41	35.51	11.07	20.71	7.80	40.22	13.43
50 - 59%	57	37.82	8.60	21.10	7.32	42.78	11.75
60 - 69%	73	35.24	11.44	20.62	6.85	40.35	14.29
70 - 79%	81	36.49	12.43	20.48	8.00	40.77	13.23
80 - 89%	46	34.56	11.61	20.24	7.02	40.28	13.45
90 - 99%	23	30.95	12.78	17.69	7.94	37.65	13.70

The distribution of mean scores follows a pattern evident in the three tests as in each there is a tendency for children with a predominantly English linguistic background, viz., the 0 - 39% group[1] to achieve relatively higher scores than children with a predominantly Welsh linguistic background, viz., the 70 - 99% group. This general tendency is somewhat disturbed by the low scores of the 40% - 49% bilingual category and the relatively high score of the 50 - 59% category. Whether this tendency indicates a statistically significant relationship between bilingualism and non-verbal intelligence or is merely due to chance may be indicated in at least two ways—

(*a*) The measure of correlation[2] between performances in the three tests and the varying degrees of Welsh linguistic background.

(*b*) The calculation of critical ratios[3] between the mean scores of the ten bilingual categories.

Table 3 shows the correlation coefficients between test scores and Welsh linguistic background.

TABLE 3

CORRELATION COEFFICIENTS BETWEEN TEST SCORES AND WELSH LINGUISTIC BACKGROUND (N = 648)

Variables Correlated	Correlation Coefficients
Welsh Background and Scores in R.P.M.	-0.1480 ± 0.0393
Welsh Background and Scores in D.F.R.	-0.1491 ± 0.0393
Welsh Background and Scores in N.V. 2.	-0.1616 ± 0.0393

The negative sign indicates that there is a tendency for scores in the three tests to decrease with increasing Welsh linguistic background and, although the three correlation coefficients are small, the three are statistically significant at the 1% level of probability.[4] This significant relationship between bilingualism and test performances suggests that children with a predominantly Welsh linguistic background are at a certain disadvantage when their performances in such non-verbal tests of intelligence are compared with those of children with a predominantly English linguistic background.

The differences in the three correlation coefficients shown in Table 3 are not statistically significant. Therefore, any of the tests used in this investigation could be used as a measure of the non-verbal intelligence of children with a mixed Welsh-

1 "Group" refers to a combination of linguistic categories.
2 See Table 3.
3 See Tables 4, 5, 6.
4 The coefficients shown above would arise from chance causes in less than 1% of similar samples.

English linguistic background without the influence of this background resulting in a significant difference between the performances in the tests. Nevertheless the influence of Welsh linguistic background is least evident in performances in R.P.M., which also proved to be the most reliable of the three tests as a measure of non-verbal intelligence. In addition there was a significant positive correlation between test scores and performance times, which indicates a tendency for higher scores to be related to longer performance times. More opportunity is given for this tendency to operate in a " power " test (i.e. one without a time-limit) such as R.P.M. than in " speed " tests like D.F.R. and N.V. 2. Thus it must be emphasised that on all three counts R.P.M. has proved to be the most suitable of the three for use in bilingual Wales.

In spite, however, of these advantages, the present investigator agrees with Banks and Sinha, who say of R.P.M.: " It would be premature to accept it in its present form when there is so much room for obvious improvement. Instead of adopting the existing version as final, it is suggested that more items should be systematically constructed in accordance with the logical principles involved, and that an endeavour should be made to increase its reliability and validity by a systematic application of the recognised methods of item analysis, preliminary scaling, and general standardisation." (17)

The reliabilities of the three tests (R.P.M. 0.9001; D.F.R. 0.8862; N.V. 2, 0.8825), though comparatively low, are not so low as to forbid their use as measures of " general intelligence " and as one of the means of " streaming " entrants to secondary schools in certain parts of Wales. While such tests are being used in this manner in mixed language areas, some account should be taken of the influence of Welsh linguistic background on test performances. The calculation of regression coefficients between linguistic background and test scores permits the prediction of test scores from a given degree of Welsh linguistic background for each child. For R.P.M., D.F.R., and N.V. 2, the regression coefficients were −0.0567, −0.0376 and −0.6717 respectively. Consequently, if the scores in the three tests are predicted from the Welsh linguistic background score, then for each child,

the deviation from the overall mean score in R.P.M. = −0.0567 times the deviation from the overall mean on the Welsh Linguistic Background Scale;

the deviation from the overall mean score in D.F.R. = −0.0376 times the deviation from the overall mean on the Welsh Linguistic Background Scale;

the deviation from the overall mean score in N.V.2 = −0.0717 times the deviation from the overall mean on the Welsh Linguistic Background Scale.

The correlation coefficients in Table 3 indicate general tendencies which exist between test performances and linguistic background and, although this is a significant tendency, such correlations do not show at what point on the Welsh Linguistic Background Scale or at what level of language saturation the effect of this linguistic background on test score is most evident. To investigate this aspect of the problem, the mean scores in the three tests of children within each bilingual category were compared with one another in order that the differences between these mean scores could be tested for statistical significance. Such a significance is most likely to occur between categories having the greatest differences in mean scores, that is, the 20-29 per cent and the 90-99 per cent categories.* However,

* See Table 2, Page 9.

as there was a certain homogeneity between the ratios at the extremities of the linguistic scale, it was decided to combine specific categories in an attempt to discover whether such a process of "slumping" would reveal further differences between the bilingual groups. For this purpose the most satisfactory combination of categories was considered to be 0 - 29%, 30 - 69% and 70 - 99% respectively. Linguistically, this division differentiates between a group (0 - 29%) with a predominantly English linguistic background, a group (70 - 99%) with a predominantly Welsh linguistic background and to whom Welsh is a first language, and an "intermediate" group (30 - 69%) with a greater degree of language mixture (as opposed to a specifically Welsh or English linguistic background) than either of the two previous groups.

The results, after combining such bilingual categories, are indicated below—

TABLE 4

CRITICAL RATIOS BETWEEN THE MEAN SCORES OF BILINGUAL GROUPS IN R.P.M.

Bilingual Group	N	Mean Score	Bilingual Group 30-69%	Bilingual Group 70-99%
0 - 29%	274	37.4343	0.0887	1.8596
30 - 69%	224	36.5848	—	1.2279
70 - 99%	150	35.0533		—

None of these ratios is significant at the 5 per cent level of probability.*

TABLE 5

CRITICAL RATIOS BETWEEN THE MEAN SCORES OF BILINGUAL GROUPS IN D.F.R.

Bilingual Group	N	Mean Score	Bilingual Group 30-69%	70-99%
0 - 29%	274	22.5145	1.8880	3.4045
30 - 69%	224	21.2633	—	1.6532
70 - 99%	150	19.9800		—

The ratios are higher than those in Table 4, that between the extreme bilingual groups (which, for convenience, may be termed "high bilinguals" and "low bilinguals") being statistically significant at the 1 per cent level of probability. Other ratios in Tables 4 and 5 indicate the homogeneity in test performances of children in the upper limits of the Welsh Linguistic Background Scale.

* The critical ratios shown above would arise from chance causes in less than 5% of similar samples.

TABLE 6

CRITICAL RATIOS BETWEEN THE MEAN SCORES OF BILINGUAL GROUPS IN N.V. 2

Bilingual Group	N	Mean Score	Bilingual Group 30-69%	70-99%
0 - 29%	274	45.1423	2.5600	3.7470
30 - 69%	224	42.1250	—	1.3990
70 - 99%	150	40.1466		—

The ratios in Table 6 repeat the pattern of those in Table 5 inasmuch as a statistically significant difference occurs between high and low bilinguals. The significance of this difference is higher than that resulting from performances in D.F.R., but in all three tests, children with a predominantly Welsh linguistic background are again shown to be at a disadvantage when general intelligence is measured in terms of such non-verbal tests. This occurs even when the instructions to the tests are presented in the language which the children can most readily understand and use. With the great majority of children in the 70 - 99 per cent bilingual category this language was Welsh.

The tables of critical ratios indicate that the intermediate (30 - 69 per cent) linguistic group bears a closer relationship to the upper (Welsh) group than it does to the lower (0 - 29 per cent) bilingual group. This suggests that the significant relationship between test performances and degrees of bilingualism extends below the lower limit of the 70 - 99 per cent bilingual group. Further comparisons made between various combinations of categories and groups indicate that, in the sample tested, there is a significant difference (at the 1 per cent level of probability) in performances in D.F.R. and

N.V. 2 between two groups whose linguistic limits are 0 - 39% and 40 - 99% respectively, the former group scoring higher.

The calculation of critical ratios between specific bilingual groups has re-emphasised that children with a predominantly Welsh linguistic background, that is, the monoglot and near monoglot Welsh children, are handicapped by their bilingualism in non-verbal tests of intelligence. The investigation has shown that this is particularly so with children in the 70 - 99% bilingual group and there is some evidence to indicate that this handicap is present in children having a bilingualism of 40%, and thereafter progressively increases. Consequently when such non-verbal tests are employed as measures of 'general intelligence' in mixed language areas in Wales, especially in conjunction with entrance examinations to Secondary Schools or for "streaming" children within a school, due regard should be taken of the handicap of children with a predominantly Welsh linguistic background. The extent of the influence of this linguistic background on performance in each of the three tests may be calculated in terms of the regression coefficients given on p. 11. Thus, in R.P.M. a child's score was reduced, on the average, to the extent of 0.567 of a mark for each degree of Welsh linguistic background as measured by the Scale. The comparable effects on D.F.R. and N.V. 2 were 0.0376 and 0.6717 of a mark respectively. (In considering these coefficients it should be borne in mind that the possible marks for the three tests are respectively 60, 45, and 85).

Throughout, the investigation has dealt with the relationship between performances in non-verbal tests and only *one* other variable, namely linguistic background, out of a complex of sociological and psychological variables. Among other variables known to affect performances in such tests are the urban-rural factor and the socio-economic or cultural-educational level of the testees' parents.

It should not be assumed, therefore, that if a child in a high bilingual category makes a low score this is simply due to a predominantly Welsh linguistic background. As a child learns and uses more English the impact of Welsh in his linguistic background tends to weaken, and his score on the Welsh Linguistic Background Scale to decrease. Consequently it may be assumed that children who remain in the predominantly Welsh group (and particularly in the 90 - 99% category) may have done so because of their restricted opportunities to learn English, combined perhaps in some cases with a lack of native ability to learn more than a modicum of the language.

In this investigation the majority of the children in the 90 - 99% category came from rural areas and had parents whose occupational level is known to have a low correlation with

mental ability. Furthermore there is evidence that rural children tend to make lower scores than urban children; this factor also would tend to depress the scores of the 90 - 99% category.

Summary

This investigation suggests that—

(*a*) in their present form, none of the tests employed can be regarded as a wholly satisfactory means of testing Welsh-speaking children if the results are to be compared with those from English-speaking children and used as a basis for the selection or "streaming" of pupils where both Welsh- and English-speakers are involved;

(*b*) children with a predominantly Welsh linguistic background tend to achieve somewhat lower scores in the three non-verbal tests used than children with a predominantly English linguistic background even when the test instructions are presented in the language apparently most familiar to the child;

(*c*) the influence of linguistic background on test performance is greatest among children whose "bilingualism" is 70% to 99% as measured with the Welsh Linguistic Background Scale;

(*d*) the influence of bilingualism is accentuated by the location of a community. Rural bilinguals, especially those with a predominantly Welsh linguistic background, achieved the lowest scores in the three tests;

(*e*) in interpreting test scores in mixed language areas due regard must be paid not only to the bilingualism of the child, but also to the occupational level or socio-economic status of his parents;

(*f*) of the three tests employed, Raven's Progressive Matrices (1938), the only untimed test, proved to be most independent of Welsh linguistic background and the most reliable measure of non-verbal intelligence, and also made allowance for the positive correlation between test scores and performance times.

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