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ABSTRACT

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AN INVESTIGATION OF THE RASCH SIMPLE LOGISTIC MODEL: SAMPLE-FREE ITEM AND TEST CALIBRATION

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An Investigation of the Rasch Simple Logistic Model:

Sample-Free Item and Test Calibration

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Gulliksen (1950) remarked over twenty years ago that the discovery of item parameters which would remain stable as the item analysis group changed would constitute a significant contribution to item analysis theory. More recently, Lord and Novick (1968) have stated a similar opinion. Within the framework of classical test theory, a number of indices of item difficulty have been suggested which might possess this property. A normal curve transformation of P values to Z values, frequently referred to as Thurstone's method of absolute scaling, has been suggested by several authors (Bliss, 1929; Guilford, 1954; Horst, 1933; Thorndike, Bergman, Cobb, and Woodyard, 1926; and Thurstone, 1925, 1947). A second method commonly suggested for obtaining invariant item difficulty parameters, the limen method, has been described by Bliss (1929), Thorndike et al. (1926), and Tucker (1952, see Angoff, 1960). Modifications of the limen method have been suggested by Gulliksen (1950) and Richardson (1936). Both the method of absolute scaling and the limen method require the assumption of a normal distribution for the ability under consideration. Although they were first described 50 years ago, neither method has been the subject of any systematic research.

In 1960, George Rasch introduced a model for the latent trait analysis of tests of intelligence or attainment; subsequent refinement of this model has continued (Rasch, 1960, 1961, 1966a, 1966b). Wright (1967) has pointed out that use of the Rasch model makes possible sample-free item and test calibration. Item and test parameters can be computed from any sample of subjects since the estimation of the parameters is independent of the distribution of ability in the calibrating sample. The purpose of this study was to investigate these claims.

The Rasch model is a special case of the logistic model; a simplified case in which the parameter for item discrimination is removed. The Rasch model makes the following assumptions:

1. Items are scored dichotomously,
2. Speed does not influence the probability of a correct response,
3. Given the parameters for item easiness (e) and subject ability (a), all responses on a test are stochastically independent, and
4. The probability of a correct response by individual i to item j is a function of the ratio a_i/e_j.

(Anderson, Kearney, and Everett, 1968; Brooks, 1965; and Sitgreaves, 1963). This last assumption excludes guessing and variations in item discrimination as factors which affect the probability of a correct response. Panchapakesan (1969) has shown, however, that the Rasch simple logistic model is robust in this respect.

Although introduced in 1960, the Rasch simple logistic model has not been widely investigated. Two research designs have been employed in the study of item calibration by the Rasch model. In the single sample design the goodness-of-fit of the item characteristic curve to the simple logistic model constitutes a test of the invariance of the item easiness estimates. (As Bock and Wood pointed out in 1971, only comparisons--contrasts or ratios--between items are meaningful because the sample-free rationale employs an arbitrary origin and unit of scale. Only the relative difficulty of items can be expressed.) Generalizations from single sample studies are limited to the range of abilities represented in the sample. In the two-sample design, the item parameters are estimated independently on data obtained from two samples of different ability. The two-sample design was employed in this research because it constitutes a more stringent test of the Rasch model.

Item Calibration. To date the published literature contains reports of only three investigations of item calibration using the Rasch model. Rasch (1960) used data from four subtests of the Danish Military Group Intelligence Test BPP which were given to 1094 Danish military recruits in September, 1953. He found the data fit his model for subtests N (a test of finding the next term in a numerical sequence) and L (a test similar to Raven's Progressive Matrices, but with groups of letters instead of geometric figures). The model was inadequate to explain performance on subtests F (in which geometric shapes are to be decomposed into parts) and V (a test of verbal analogies). Rasch, however, had used restrictive time limits with subtests F and V. When the time factor was controlled the data for these subtests also fitted his model (Rasch, 1966a).

Brooks' (1965) research was designed to determine whether data obtained from American public school children with a group intelligence test would fit the Rasch model. Samples of 509 eighth graders and 544 tenth graders in Iowa Public Schools (all of whom had served as part of the standardization sample for the 1964 Lorge-Thorndike Intelligence Test) were employed in this study. The data for the eighth grade students were analyzed for all eight subtests while the data for the tenth grade students were analyzed for only three subtests: verbal 3, written arithmetic problems, verbal 5, word analogies, and non-verbal 3, geometric form analogies. In all, 178 items were tested at the eighth grade level and 65 items were tested at the tenth grade level; 177 (72.8%) of the 243 items tested fit the Rasch model, supporting the hypotheses that the Rasch model is appropriate for representing performance on a standardized, multiple choice test of intellectual ability, and that Rasch item easiness estimates are invariant with respect to the ability of the calibrating sample.

Brooks (1965) also investigated the invariance of item easiness estimates derived independently from two samples of differing ability. He reports the results of this analysis in terms of an I index, obtained by taking the square root of the mean of the squares of the perpendicular distance of the item points from the line dictated by the model. Brooks concludes that the points generally tended to fall along a straight line with unit slope but that these comparisons are somewhat difficult to evaluate.

Among the hypotheses investigated by Anderson et al. (1968) were the following:

1. Rasch item easiness estimates are independent of the ability of the calibrating sample, and
2. Rasch item easiness estimates are more stable when items which fit the Rasch model are considered.

The test used in this research was the 45-item spiral omnibus intelligence test, used for screening applicants who apply to join the Australian Army or Royal Australian Navy. One sample consisted of 608 recruit applicants to the Citizen Military Force (CMF), a part-time system of military training. The second sample consisted of 874 recruit applicants to the Royal Australian Navy (RAN). This latter sample was actually composed of three types of examinees, 446 general service recruits, 129 reservists (the RAN equivalent of the CMF), and 279 recruits to the womens section of RAN. Twelve items were deleted for zero or 100% correct responses and the ability dimension was categorized into six levels which corresponded to cut off points used by the military.

The hypothesis that Rasch item easiness estimates are independent of the ability of the calibrating sample was first investigated using a single-sample design. For the CMF sample 30 (91%) of the items fit the Rasch model at the .01 level of confidence, 25 (76%) of the items fit the Rasch model at the more stringent .05 level of confidence. (The level of confidence represents the probability of obtaining the observed pattern of responses, assumimg the Rasch model is adequate to explain performance on the item. A .01 level of confidence indicates that the observed pattern of responses would occur only one time in 100 for items which fit the Rasch model. Thus, the reverse of the normal situation occurs with the .05 level of confidence representing a more stringent criterion than the .01 level of confidence.) For the RAN sample the corresponding values were 22 (67%) and 16 (48%). The authors concluded that these results support the hypothesis for the range of abilities represented by the samples.

Anderson, et al. (1968) also employed a two-sample design in investigating this hypothesis. This was accomplished by computing the product-moment correlation between the item easiness estimates obtained from the CMF and RAN samples. The authors concluded from the correlation of .958 that the item easiness estimates were independent of the ability of the samples upon which they were computed. This correlation was based on all 33 items. Only those items satisfying the Rasch model, however, can be expected to possess the properties attributed to the model. Accordingly, when those items that failed to fit the Rasch model at the .05 level were deleted, a correlation of .990 was obtained between the remaining item easiness estimates. This compares favorably with the correlation of .958 obtained when comparing all items.

<u>Test Calibration</u>. Only two investigations have been published regarding the use of the Rasch model to achieve sample-free test calibration. When the

Rasch model is used to calibrate a test, logarithmic ability estimates are assigned to every possible raw score from 1 to K-1. These scores indicate the amount of ability required to achieve that score. A comparison of the logarithmic ability estimates assigned to a test by two samples of different ability should indicate the degree to which the corresponding raw score groups are assigned the same ability estimate by the two samples. Wright (1967) reports one investigation based on the responses of 976 beginning law students to 48 reading comprehension items on the Law School Admission Test. To obtain samples of different ability, Wright selected two comparison groups from his total sample. The "dumb group" included the 325 students who did poorest on the test. The top score in this group was 23. The "smart group" included the 303 students with the highest scores. The lowest score in this group was 33, leaving a ten point difference between the smartest person in the "dumb group" and the dumbest person in the "smart group". The test was calibrated separately on the two groups and the results were presented graphically. Wright compared the similarity between the two sets of logarithmic ability estimates and two sets of percentile ranks and concluded that the Rasch model does lead to sample-free test calibration while the "traditional" method does not.

Anderson et al. (1968) also addressed themselves to this question. They correlated the ability estimates assigned to the six ability groupings on the basis of the CMF sample with those obtained from the RAN sample. The resulting product-moment correlation of .992 was interpreted as evidence that the ability estimate assigned to a score on a test is independent of the distribution of ability in the calibrating sample.

In summary, few studies have been published on the use of the Rasch model in item and test calibration. The invariance of Rasch item easiness ratios with respect to the ability of the calibrating sample has been studied by Anderson et al. (1968), Brooks (1965) and Rasch (1960). The use of the Rasch model to achieve sample-free test calibration has been studied by Wright (1967) and Anderson et al. (1968). It is apparent that more studies of sample-free item and test calibration with the Rasch model remain to be performed before the model's usefulness can be fully assessed.

This paper examines the application of the Rasch model to analogy items. The following hypotheses were investigated:

1. Rasch item easiness estimates are invariant with respect to the ability level of the calibrating sample.
2. The higher the probabilities that the individual items fit the Rasch model, the more invariant the item easiness estimates are with respect to the ability level of the calibrating sample.
3. Rasch ability estimates, assigned in the calibration of a test, are invariant with respect to the ability level of the calibrating sample.

Hypotheses 1 and 2 are tests of the invariance of the Rasch item easiness estimates; hypothesis 3 is a test of the invariance of the ability estimates assigned to a test. To provide a base line against which the invariance of the Rasch item easiness estimates can be compared, a conventional item easiness parameter--2 item difficulty index--was also calculated and submitted to similar tests.

METHOD

Selection of Item Format. Spearman's "g" or general mental ability is a complex, somewhat poorly defined construct which seems to be represented in almost all the major intelligence tests in use today. Helmstadter (1964) points out that tests dealing with abstract relationships (such as verbal, numerical, or symbolic analogies) come closest to representing what is meant by "g". For this reason, the analogy format was selected for study in this research. Guilford (1959) suggests that there are several meaningfully different methods of asking analogy questions. In his Structure of Intellect the analogy format tests the ability to "recognize relationships". This general ability can be factored into abilities at recognizing figurally, symbolically, semantically, and behaviorally presented relationships, depending upon the type of material used to present the question. To make the results as general as possible, it was decided to study figural (picture), symbolic (number and symbol), and semantic (word) test items. Two types of symbolic material were used because of the intrinsic differences in the two, and because Guilford (1966) reports several instances in which cells in his Structure of Intellect contain more than one factor.

Subjects. Data were obtained for four samples of subjects. College students enrolled in an introductory psychology class at the University of Minnesota completed 1404 test booklets. Each student was a volunteer who participated in the experiment to earn additional points towards his course grade. The students were given the option of completing 1, 2, or 3 test booklets, hence the exact number who participated in the experiment is not known. High school students enrolled in two suburban Twin Cities high schools completed 484 test booklets. Each student completed one test booklet. In both schools the test booklets were completed by students in the classes of those teachers who volunteered to participate in the study. Civil service clerical employees of the City of Minneapolis completed 289 test booklets as part of a battery of tests. Finally, 90 clients of the Minnesota State Division of Vocational Rehabilitation (DVR) completed a short word analogy test as part of a vocational assessment test battery.

The samples, for the most part, were similar in race, religion, and sex composition. The high school and college students were younger than the

DVR clients and civil service employees, had fewer marital obligations, were better educated, and came from homes with higher family incomes, better educated mothers, and fathers employed in higher level occupations. In comparison with the high school and college students, the civil service employees were older, had lower family incomes, and were far more likely to be married and have children. The DVR clients, while heterogeneous in many respects, were less well educated and had lower family incomes than the high school and college students.

Instruments. The four basic tests designed for use in this study were a 60-item word analogy test, a 60-item number analogy test, a 50-item picture analogy test, and a 40-item symbol analogy test. (For a discussion of the test construction process, see Tinsley, 1971.) None of the tests employed time limits although time limits were imposed by the setting in which the tests were administered. Because of time limitations inherent in the college and high school settings, it was desirable to have tests which would require an average of 50 to 60 minutes to complete. For this reason, the four tests were combined into two test booklets. Form WS-100 contained the 60-item word analogy test and the 40-item symbol analogy test; form NP-110 contained the 60-item number analogy test and the 50-item picture analogy test. A fifth test designed for use with the DVR clients, form W-25, contained 25 word analogies. This short test was administered alone in order that the testing time for DVR clients could be kept to an absolute minimum.

Results on two additional tests are reported herein even though the data were collected for use in another study. The items of interest, 30 picture and 30 word analogies, were presented in two different test booklets. Form WP-60, containing these 60 items, was administered to Minneapolis civil service employees. Form MNWP-110, containing these items plus 50 number analogies, was administered to college students. These word and picture analogies had been selected in an unusual manner. The picture items had been selected from the picture items surviving an iterative item analysis procedure (for details, see Tinsley, 1971). The word analogies were then constructed from the picture analogies by substituting, in the place of the picture, the word for the object in the picture. The resulting 30 word analogies have undergone no formal item analysis. None of these word analogies appearson form WS-100.

Each analogy item presented five alternative answers, only one of which was correct. Because the test booklets used in this research had been designed to be self-explanatory, examinees were simply given the test booklet and answer sheet and were instructed to read the directions and complete the test. An examiner was always available, however, to answer any questions. The college students were the only group to complete more than one test booklet. For approximately half the college students the order of administration was WS-100, NP-110, and MNWP-110. For the other half the order of administration was NP-110, MNWP-110, and WS-100.

Analysis. Before formal analysis of the data was begun, the data were edited to eliminate presumably careless or slow examinees. This was accomplished by elim!uating from the study any examinee who left several consecutive items blank, who left blank the last few items in a test, or who left blank more than five items in the entire test booklet. For forms WP-60 (administered to Minneapolis civil service employees), MNWP-110 (administered to college students), and W-25 (administered to DVR clients) no blank responses were tolerated because the forms were so short. For college students, 5 NP-110 and 1 MNWP-110 test booklets were eliminated. For high school students, 3 word tests, 14 symbol tests, 17 number tests and 42 picture tests were not used. The higher percentage of high school students who failed to complete their test booklets was due to the limited time available for testing. The students were allowed only one 50 minute class period to complete the test booklet. Only 1 DVR client and 20 civil service employees failed to complete their tests.

The scored item responses were then submitted to analysis. Calculation was performed using a computer program written by Wright and Panchapakesan (1969, 1970) and modified by Bart, Lele, and Rosse (1970) for use on the University of Minnesota's Control Data 6600 computer.

The first question of interest was whether the use of the Rasch model leads to item easiness estimates that are invariant with respect to the ability of the calibrating sample. Ten tests were attempted in this study (see Table 1). In each case a set of analogy items was completed by two subsamples of different ability, the two sets of data were independently submitted to item analysis, and the product-moment correlation was calculated between the two sets of Rasch item easiness estimates and, for comparison purposes, between the two sets of Z item difficulty estimates. For the data to support the conclusion that item parameters are invariant with respect to the ability of the calibrating sample, the correlation between the two appropriate sets of data must approach unity. This determination was made by inspection of the pattern of observed correlations.

Insert Table 1 about here

The relationship between the "goodness-of-fit" of the item and its invariance was also studied. First, the Rasch item easiness estimates derived from two groups were correlated across all items. Then those items which failed to fit the Rasch model for both groups at the .01 level of confidence were removed and the correlation was recomputed. This procedure was also followed using the .05, .10, .25, .30, .35, and .40 levels of confidence. A similar procedure was employed in investigating the relationship between the invariance of the Z item difficulty estimate and the "goodness-of-fit" of the P value. The criteria used in this instance were $.20 \leq P \leq .80$, $.30 \leq P \leq .70$, and $.40 \leq P \leq .60$. In both cases, the hypothesis was that the product-moment correlation between item parameters would increase as the criterion became more stringent.

Finally, the invariance of the ability estimates computed for each raw score was investigated by computing the product-moment correlation between two sets of independently obtained ability estimates.

RESULTS

Item Calibration. Ten sets of data were collected which were relevant to an investigation of the invariance of Rasch item easiness and Z item difficulty estimates (see Table 1). In each case, independent estimates of the easiness of the items in the test, obtained from two samples of different ability, were correlated. Tables 2 and 3 indicate the results of these analyses.

Insert Tables 2 and 3 about here

In all but one comparison the correlation between independent estimates of Rasch item easiness differ no more than one point from the correlation between independent estimates of Z item difficulty. Four tests of the invariance of the item parameter estimates were conducted with word analogies. The Rasch item easiness estimates obtained from college students on a 60-item word analogy test correlated .95 with those obtained from high school students (comparison I) while the item easiness estimates obtained from college students on a 30-item word analogy test correlated .91 with those obtained from civil service employees (comparison IV). At the other extreme, the Rasch item easiness estimates obtained from college students and high school students had zero correlations with those obtained from DVR clients (comparisons II & III). Four tests of the invariance of the item parameter estimates also were conducted with picture analogies. The Rasch item easiness estimates obtained from college students on a 50-item test correlated .97 with those obtained from high school students (comparison V), while the item easiness estimates obtained from college students on a 30-item picture analogy test correlated .88 with those obtained from civil service employees (comparison VIII). The Rasch item easiness estimates obtained from college and high school students on 25-items embedded in the 50-item picture analogy test correlated .29 and .32 respectively with the item easiness estimates obtained from civil service employees on those 25-items embedded in the 30-item picture analogy test (comparisons VI & VII). A single comparison (X) of item parameter estimates obtained from college and high school students on a 40-item symbol analogy test yielded a correlation of .98 between the Rasch item easiness estimates. And, finally, a comparison (IX) of item parameter estimates obtained from college and high school students on a 60-item number analogy test resulted in correlations of .93 between the Rasch item easiness estimates and a correlation of .97 between the Z item difficulty estimates.

The above results indicate the degree to which the item parameter estimates are invariant when the analysis is performed on all items in the test. The Rasch model, however, cannot be expected to hold for items which do not fit the model. For this reason, the relationship between the invariance of the item parameter estimates and the "goodness" of the item was investigated. This relationship is relatively simple for the Z item difficulty estimates. In general, the less restrictive the range of acceptable item difficulties, the higher the correlation. In the six Z item difficulty comparisons in which correlations of .89 or higher were obtained (comparisons I, IV, V, VII, IX, & X), the highest correlation is observed when all items are included in the comparison and the correlation drops with each restriction of the range of acceptable item difficulty. In the four remaining comparisons (II, III, VI, & VII), the correlations fluctuate randomly with each restriction of the range of acceptable item difficulty.

Elimination of items which did not fit the Rasch model resulted in increases in the correlation between Rasch item easiness estimates. However, the results did not follow a single pattern. Only the comparison of the Rasch item easiness estimates obtained from college students and civil service clerical employees on 30 picture analogies (comparison VIII) showed a steady decrease in correlation as items with lower Rasch probabilities were removed. Item easiness estimates obtained from high school students and civil service employees on 25 picture analogies (comparison VII) showed an initial increase in correlation when those items with Rasch probabilities below .01 were removed. The correlation fell to zero, however, when those items with Rasch probabilities below .05 were removed, and fluctuated randomly with subsequent deletions of items. Item easiness estimates obtained from college and high school students on 60 number analogies (comparison IX) increased in correlation when items with Rasch probabilities below .01 were deleted, and remained stable until after deletion of items with Rasch probabilities below .25. At that point, the correlation began an uninterrupted drop.

The remainder of the comparisons showed some increase in correlation as items with low Rasch probabilities were deleted. In the comparison of item easiness estimates obtained from college students and civil service employees on 30-word analogies (comparison IV) the increase was somewhat erratic, and in the comparison of item easiness estimates obtained from college students and DVR clients on 25-word analogies (comparison II) negative correlations were obtained. But this latter comparison and the comparisons of college and high school students on 60-word analogies (comparison I), on 50-picture analogies (comparison V), and on 40-symbol analogies (comparison X) all correlated .99 when items with low Rasch probabilities were removed.

Test Calibration. It is very rare for educational or psychological measurement to be made with only one item. In practice, tests of ability contain several items and the overall performance of the examinee is the basis from which generalizations about ability are made. The Rasch model takes account of the easiness of the items in a test in estimating the amount of ability indicated by raw scores on that test. It is appropriate, therefore, to ask whether the ability estimates assigned to test scores are invariant with respect to the ability of the calibrating sample. In each of the ten cases investigated (see Table 2), the product-moment correlation between the Rasch ability estimates was .999. Figure 1 illustrates the relationship between the ability estimates calculated for a 25-item word analogy test from the responses of 630 college students and 89 DVR clients (comparison II).

Insert Figure 1 about here

DISCUSSION

Item Calibration. Ten tests of the invariance of Rasch item easiness estimates and Z item difficulty estimates were made with mixed results. The results are not so equivocal as they appear, however. Anderson et al. (1968) point out that the Rasch model does not lend itself to small samples. Generally, samples of 500 or larger are needed to obtain stable item easiness (and ability) estimates. It is important, therefore, to keep the size of the sample in mind in interpreting the results. The comparison of item easiness estimates obtained from 630 college students with those obtained from over 300 high school students (comparisons I & X, on 60 word analogies and 40 symbol analogies) yielded correlations of .95 and .98. Correlations of .97 and .93 were observed when the item easiness estimates obtained from 492 college students were compared with those obtained from 120 high school students (comparison V on 50 picture analogies) and from 145 high school students (comparison IX on 60 number analogies). And the comparison of item easiness estimates obtained from [illegible] college students and from 269 civil service employees on 30 word and on 30 picture analogies (comparisons IV & VIII) yielded correlations of .91 and .88. In contrast, the two comparisons involving item easiness estimates obtained from 89 DVR clients (comparisons II & III) resulted in zero correlations. It appears, therefore, that six of the comparisons of item easiness estimates made in this research yielded invariant item easiness estimates, especially considering the small sample sizes employed. Two of the four comparisons which did not support the hypothesis of invariant item easiness estimates are invalid because of the extremely small sample size.

Two comparisons (VI & VII) remain, however, which did not support the hypothesis. Both were based on small samples but the samples were larger than samples used in some comparisons which did support the hypothesis. It is possible that the nature of the test was a factor in these results. Both comparisons involved the item easiness estimates obtained from civil service employees for 25 of the 30 picture analogies on form WP-60. (Form WP-60 consisted of 30 analogies expressed in word form followed by the same 30 analogies expressed in picture form.) It seems likely, therefore, that the estimates obtained from the civil service employees were contaminated by some factor other than ability and item difficulty. This factor might have been the recognition of some of the picture analogies as identical to the preceding word analogies.

Another factor which may have served to reduce the invariance of the item easiness estimates must be mentioned briefly. Panchapakesan (1969) provides a criterion for the elimination of examinees with low scores so that the estimation of item easiness will not be contaminated by guessing. According to her criterion, some of the subjects in this study should have been eliminated. Because of the initially small sample size, this procedure was not followed. It is possible, therefore, that guessing may have reduced the invariance of the item easiness estimates in some instances.

In summary, six of the ten comparisons supported the hypothesis that the Rasch item easiness estimates were invariant with respect to the ability of the calibrating sample, even though a number of the comparisons involved samples of questionable size. Of the four remaining comparisons, two included samples so small as to invalidate the results while the other two were invalid because the Rasch model was not appropriate for tests designed in that manner.

It must be noted, however, the results of the Z item difficulty estimates compare well with those for the Rasch item easiness estimates. There is no basis from these data for choosing between the two item parameters. Such choice could be made on the basis of the assumptions involved in the two parameters. The Z item difficulty estimate requires the assumption that the sample is normally distributed while the Rasch item easiness estimate requires no assumption about the ability of the calibrating sample. It should be noted, parenthetically, that either the samples used in this study were normally distributed in terms of ability or that Z item difficulty estimates are robust for the assumption of normality.

The above results represent a stringent test of the Rasch model in that items for which the Rasch model is clearly inappropriate were included in the comparison. Deletion of these items should result in an increase in the correlation of the item easiness estimates obtained from different samples. This result was observed for five of the six valid comparisons. In three of these comparisons (I, V, & X) the correlation increased to .99. In the other two cases (comparisons IV & IX) the correlation increased at first and then decreased. In both such instances, the number of items remaining had grown so small that the lowering of the correlation may have resulted from a restriction of the range of item easiness estimates. Only the results obtained when comparing the item easiness estimates obtained from 269 civil service employees and from 276 college students (comparison VIII) for 30 picture analogies failed to support this hypothesis. Both samples completed these picture items after completion of 30 word analogies having identical relationships. Therefore, the resulting item easiness estimates may have been contaminated.

Test Calibration. It was hypothesized that Rasch ability estimates are invariant with respect to the ability of the calibrating sample. The results of each of the ten comparisons support this hypothesis. Even in those instances in which the samples were so small that the individual item easiness estimates were sample dependent, the resulting ability estimates were invariant. This is important because test items are almost always administered in groups. These results indicate that the ability estimates assigned to any collection of 25 or more items will be invariant with respect to the ability of the calibrating sample, regardless of whether the separate item easiness estimates were invariant or not.

The implications of this finding and of the earlier finding of the invariance of the item easiness estimates, given a sufficiently large sample, should not be ignored. The estimation of the amount of ability indicated by a raw score on a test is based upon the aggregate difficulty of the items in that test. The preceding results indicate that the calculation of the difficulty of the items and the subsequent calibration of the test in terms of the amount of ability represented by each raw score can be made from any sample. The researcher need not be concerned with the distribution of level or ability in the calibrating sample; the calibration of a test is independent of these factors.

CONCLUSIONS

The results of this research support the following conclusions:

1. Rasch item easiness estimates are invariant with respect to the ability of the calibrating sample when an adequate sample is employed.
2. Invariance of the Rasch item easiness estimates is related to the goodness-of-fit of the items to the Rasch model. The deletion of items with low Rasch probabilities increases the invariance of the Rasch item easiness estimates.
3. The estimation of the amount of ability indicated by the raw scores on a test is invariant with respect to the ability of the calibrating sample for tests of 25 or more items even when relatively small samples are employed.

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Table 1

Comparisons Made in Testing Invariance
of Rasch Item Easiness Estimates

Analogy Items			Sample and Source of Items					
Type	Number	Comparison code	Sample 1	N	Form	Sample 2	N	Form
Word	60	I	College	630	WS-100	High School	319	WS-100
	25	II	College	630	WS-100	DVR clients	89	W-25
	25	III	High School	319	WS-100	DVR clients	89	W-25
	30	IV	College	276	MNWP-110	Civil Service	269	MNWP-110
Picture	50	V	College	492	NP-110	High School	120	NP-110
	25	VI	College	492	NP-110	Civil Service	269	WP-60
	25	VII	High School	120	NP-110	Civil Service	269	WP-60
	30	VIII	College	276	MNWP-110	Civil Service	269	WP-60
Number	60	IX	College	492	NP-110	High School	145	NP-110
Symbol	40	X	College	630	NP-110	High School	308	NP-110

Table 2

Correlation of Rasch Item Easiness Estimates

Minimum Rasch Probability	Comparison and Type of Analogies: WORD I	II	III	IV	PICTURE V	VI	VII	VIII	NUMBER IX	SYMBOL X
All Items	.95	-.08	.05	.91	.97	.29	.32	.88	.93	.98
.01	.95	-.12	.12	.89	.97	.28	.46	.85	.96	.98
.05	.95	-.01	.05	.93	.98	.30	-.08	.84	.96	.98
.10	.95	-.73	.21	.90	.98	.30	-.08	.79	.95	.99
.25	.96	-.62	.40	.95	.98	.50	.09	.84	.92	.99
.30	.97	-.62		.96	.98	.49	.34	.73	.83	.99
.35	.98	-.99		.94	.99	.49	.34	.64	.77	.99
.40	.99			.94	.99	.41	.08	.18	.62	.99
Number of Items										
All Items	60	25	25	30	50	25	25	30	60	40
.01	54	19	19	25	49	20	20	23	50	26
.05	39	15	16	16	33	15	13	18	39	22
.10	26	11	10	12	27	14	12	14	26	16
.25	17	6	4	7	14	7	5	11	12	12
.30	13	6	2	6	13	6	4	8	10	9
.35	8	4	1	4	8	6	4	6	8	6
.40	5	1	1	[illegible]	5	4	3	4	6	6

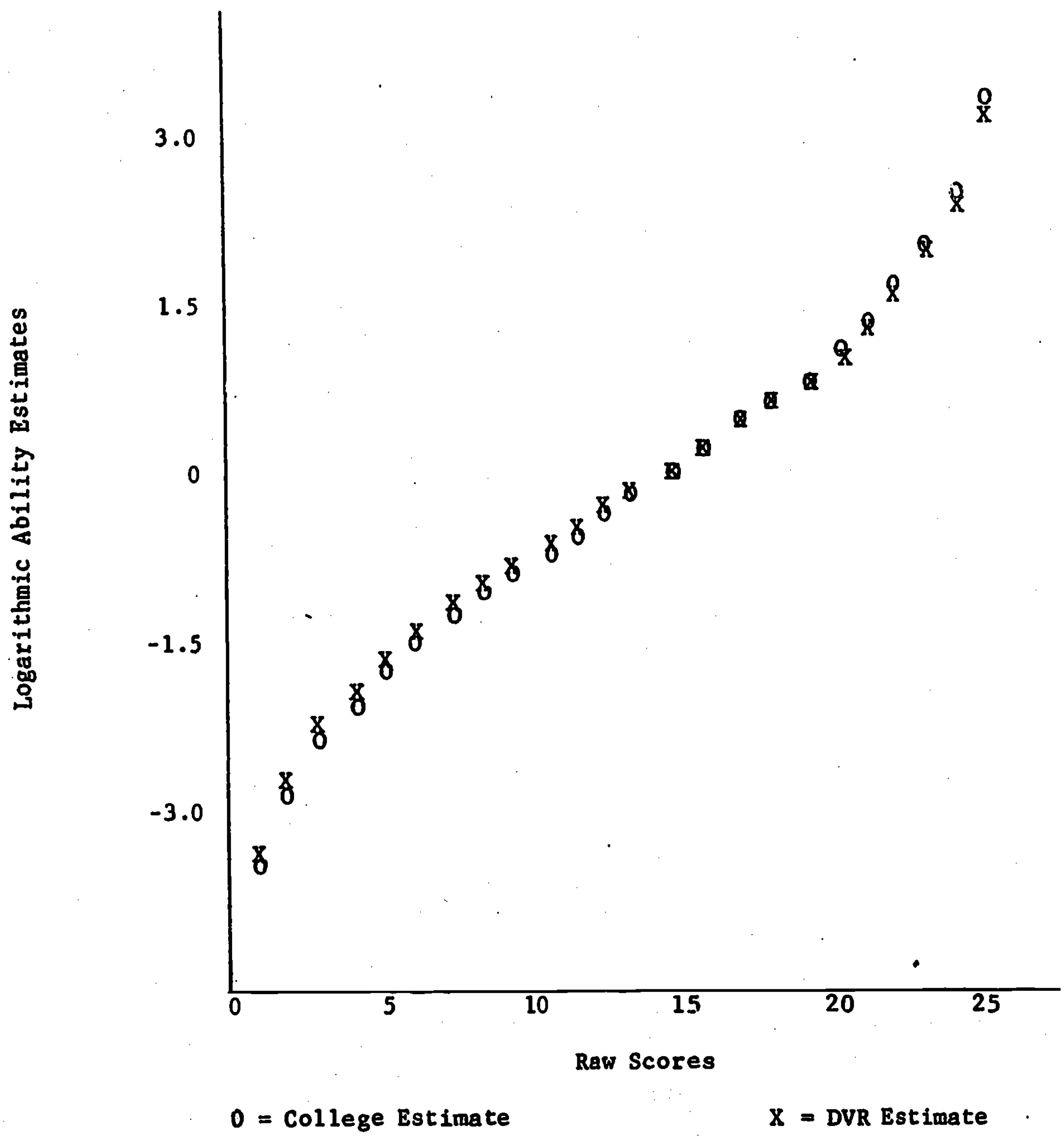
Table 3

Correlation of Z Item Difficulty Estimates

Acceptable Item Difficulties	Comparison and Type of Analogies									
	WORD				PICTURE				NUMBER	SYMBOL
	I	II	III	IV	V	VI	VII	VIII	IX	X
All Items	.96	-.08	.04	.91	.97	.30	.33	.89	.97	.98
.20 - .80	.91	-.15	-.38	.76	.92	.21	.15	.79	.90	.92
.30 - .70	.76	.20	-.12	.24	.89	.41	-.40	.60	.85	.83
.40 - .60		-.50	-.16		.60					
	Number of Items									
All Items	60	25	25	30	50	25	25	30	60	40
.20 - .80	39	18	22	16	31	17	20	17	25	20
.30 - .70	19	8	19	6	20	9	7	10	17	13
.40 - .60	2	4	7	1	5	1	1	2	3	3

Figure 1

Invariance of Rasch Ability Estimates



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