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PRL-TDR-62-12

Prediction of Technical School Success from Homogeneous Biographical Inventory Scores

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By
Leland D. Brokaw

Technical Documentary Report PRL-TDR-62-12
July 1962

6570TH PERSONNEL RESEARCH LABORATORY
AEROSPACE MEDICAL DIVISION
AIR FORCE SYSTEMS COMMAND
Lackland Air Force Base, Texas

Project 7717, Task 771705

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PREDICTION OF TECHNICAL SCHOOL SUCCESS
FROM HOMOGENEOUS BIOGRAPHICAL INVENTORY SCORES

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FOREWORD

Dr. Marvin H. Berkeley, now with Texas Instruments, Inc., Dallas, Texas, developed most of the inventory materials on which this study is based.

The magnetic tape records of item responses were prepared under Contract AF 41(657)-250 by the Data Processing Center, San Antonio, Texas, under the direction of Mr. George A. Reilly.

ABSTRACT

A personal questionnaire, the Biographical Inventory, was part of the airman classification batteries up to 1959, with separate groups of items keyed for different job areas. This paper reports how the items of the most recent classification battery were assorted into 15 clusters on the basis of high correlations among items of each cluster. The scores for each group (homogeneous keys) were correlated with success in training for graduates of 8 Air Force training schools. The keys for Economic Level and Educational Success were the most generally valid. By multiple regression techniques, it was found that prediction of training school grades was almost as good from a regression equation based on graduates from all 8 schools as from separate equations for schools in each job area. Composite scores combining the inventory scores and the aptitude index were significantly more valid than the aptitude indexes alone (average .43 vs .46); but a simplified combination of the 3 or 4 most valid inventory keys with the aptitude index proved equally valid. Under conditions existing at the time these data were collected, a short biographical inventory consisting of 4 or 5 of the homogeneous scales would add significantly to the validity of aptitude indexes derived from the last Airman Classification Battery.

This report has been reviewed and is approved.

Fred E. Holdrege, Col USAF
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PREDICTION OF TECHNICAL SCHOOL SUCCESS FROM HOMOGENEOUS BIOGRAPHICAL INVENTORY SCORES

1. INTRODUCTION

Air Force selection and classification programs have made use of biographical inventories for many years. Traditionally these instruments have been applied through the development of keys against an empirical criterion measure, usually success in Air Force training. This approach results in piecemeal evaluation of biographical materials against isolated criteria and is cumbersome when new specialties appear for inclusion.

As a more efficient approach to biographical materials DuBois, Loevinger, & Gleser (1952) proposed a technique of "homogeneous" keying. This procedure provides scores for unitary personal characteristics based on objective evaluation of the homogeneity of groups of items. The rationale is that different combinations of such scores might be determined for different criteria through regression procedures, in the same manner as for traditional aptitude scores. Such quality, if realized, would eliminate piecemeal key development for each specialty and improve the effectiveness of prediction.

Evaluations of various methods of using item analysis to key biographical materials have been completed by Lecznar (1951) and Pickrel (1954). Lecznar demonstrated that keys based upon patterns of response, where the size and sign of phi coefficients follow a continuum between the sequential responses of an item, were more stable than keys based solely upon the selection of those choices for keying whose phi coefficients exceeded a given level of significance. Pickrel supported this finding, and also found that homogeneous groups of items made more substantial contribution to composite scores involving aptitude tests than did the pattern keys.

This report covers the validation of such homogeneously keyed materials on a fairly broad spectrum of Air Force enlisted technical training.

2. BACKGROUND

Responses of basic airmen to the questions of the biographical inventory included in Airman Classification Battery AC-1B were used by DuBois, Loevinger, & Gleser in the development of the homogeneous keying technique. Conclusions from the research were that the technique was feasible, but that the biographical materials provided in the airman classification program were not sufficiently varied to permit coverage of personal characteristics deemed necessary.

An experimental inventory later was prepared intended to meet the criteria of breadth of topical coverage and suitability for heterogeneous populations of examinees. Berkeley¹ reported that the inventory is suitable for young adult males and is keyed in multiple subtests which may be weighted to predict available criteria. The survey was developed after review of the major biographical areas covered by previous Air Force and commercial inventories. The *a priori* areas covered by the survey include: physical condition and health, scholastic achievement, physical characteristics of educational institution attended, introversion-extroversion, familial structure and social activities, religion, economic background, childhood responsibilities, and itinerant history.

¹ Unpublished technical memorandum by Marvin H. Berkeley, "The development of homogeneous subtests of Biographical Inventory BE-CE601DX2," 19 Aug 54, on file in 6570th Personnel Research Laboratory (PRS).

The biographical materials included in a more recent form of the Airman Classification Battery, AC-2A, as reported by Brokaw and Burgess (1957) were assembled to permit derivation of scores for selected homogeneous keys from an earlier analysis of the previous form and the experimental inventory. A description of the item content of each of the keys included in the biographical material for Airman Classification Battery AC-2A, for which validation data are presented in this report, appears in the Appendix. The titles of the keys are:

- | | |
|------------------------|--------------------------------------|
| 1. Cultural | 9. Light Leisure |
| 2. Domestic | 10. Literary |
| 3. Economic | 11. Parental Distance (Broken Home) |
| 4. Educational Success | 12. Parental Distance (Foreign Born) |
| 5. Extroversion | 13. Reading |
| 6. Itinerant | 14. Stenographic |
| 7. Large Family | 15. Urban |
| 8. Late Child | |

3. THE PRESENT STUDY

Although the above listed scores were not derived in the operational classification program all necessary items were answered by every airman who took Airman Classification Battery AC-2A. Item responses were translated into magnetic tape records for a substantial sample of technical school trainees. These data permit item validation across 25 Air Force technical schools for airmen enlisting in the period between 1 January 1956 and 1 March 1957.

This study involves 4,853 graduates distributed among eight technical schools—two schools under each of the four selective aptitude indexes. Each pair of schools was selected as representative of specialty training requiring a qualifying score on the selective aptitude index, but as different from each other as possible. For example, in each area one specialty was chosen for which the minimum recommended qualifying level was low, and the other specialty had a fairly high recommended minimum qualifying score. This attempt to maximize differences within, as well as between, selective indexes was partially frustrated by the generally low aptitude level of airmen enlisting during the period covered.

The analysis was designed to answer two questions. First, were the homogeneous subscales valid for the specialties? Second, would the homogeneous subscales make significant contribution to the selection or classification of Air Force enlisted personnel beyond that available in the operational test scores?

The answers to these questions were sought through analyses designed to give information as to the efficiency of the optimal combination of the homogeneous keys for prediction of criteria of technical school success. Multiple correlations of the 15 scores based upon the keys were computed for each technical school group separately, for the two schools falling under each selective aptitude index combined, and for all eight schools taken as a single group. This approach would establish the extent to which individual keys might be predictive of individual schools, or of the schools believed sufficiently similar to be grouped under the same selector index. The group of all schools was included to determine whether the valid material in the homogeneous keys was more related to the general criterion of technical training success than to the criteria specific to a given specialty.

4. RESULTS

The validity of each homogeneous key for each of the criterion groups specified above is presented in Table 1. The Educational Success and Economic scales show significant and reasonably

consistent validity across all groups. The Domestic, Light Leisure, Parental Distance (Foreign Born), and Parental Distance (Broken Home) scales, while showing low numerical validity, tend to be consistent as to sign across all specialties. The multiple correlation of the 15 scores with the technical school grade for each of the criterion groups is given in Table 1.

Multiple correlations derived by the Bottenberg technique (1960) showed some variation between samples and suggested that the equation based upon the criterion sample of all eight schools would provide more consistent predictive efficiency across all specialties than would the equations based upon any school or pair of schools. An exception was the composite based upon the pair of Administrative schools, which seemed sufficiently different to merit individual evaluation. Therefore each of the

TABLE 1. Technical School Validity of Homogeneous Scores Derived From the AC-2A Biographical Inventory

Scale	N:	Criterion Group ^a												
		1	2	3	4	5	6	7	8	1+2	3+4	5+6	7+8	1-8
Cultural	738	-.05	.03	-.02	-.08	-.03	.04	.04	-.06	-.02	-.04	.00	.00	-.02
Domestic	690	-.08	-.02	-.05	-.16	-.05	-.07	-.04	-.01	-.06	-.08	-.06	-.04	-.06
Economic	593	.18	.14	.08	-.01	.05	.12	.14	.04	.17	.05	.08	.12	.12
Educational Success	267	.26	.23	.17	.21	.34	.22	.29	.20	.25	.17	.27	.26	.23
Extroversion	819	-.04	.14	.03	-.05	-.01	.02	-.05	-.06	.04	.00	.01	-.06	.01
Itinerant	554	-.05	.00	.03	.05	-.05	.05	-.06	-.14	-.03	.04	.00	-.08	-.01
Large Family	759	-.11	-.08	-.01	.04	.08	-.02	-.07	-.03	-.10	.01	.03	-.07	-.04
Late Child	433	-.04	-.06	-.06	.03	.02	-.05	-.08	-.01	-.05	-.03	.00	-.05	-.04
Light Leisure	1428	-.10	-.01	.02	-.04	-.03	-.04	-.06	-.03	-.06	.00	-.03	-.06	-.05
Literary	860	.05	.16	.00	-.11	-.01	.00	.03	-.02	.10	-.04	.00	.03	.02
Parental Distance(BH)	1373	-.09	-.09	-.15	.02	-.08	-.13	-.02	-.03	-.09	-.10	-.10	-.03	-.09
Parental Distance(FB)	1192	.02	.03	.08	.14	.04	-.07	.00	.04	.03	.10	-.02	.04	.02
Reading	4853	.01	.09	-.05	-.02	.04	.05	.08	-.02	.04	-.04	.02	.04	.02
Stenographic		.02	.12	.17	.15	.05	-.01	.02	-.03	.06	.14	.02	.01	.03
Urban		.07	.05	.02	-.03	.00	.02	.12	.07	.07	.00	.00	.11	.05
Multiple Correlation ^b		.36	.31	.33	.39	.38	.30	.36	.30	.32	.29	.32	.33	.29
Mechanical AI		.52	.35							.46				.30
Administrative AI				.41	.27						.23			.26
General AI						.49	.41					.44		.43
Electronics AI								.60	.41				.54	.44
Selective AI Mean		63.8	52.5	44.3	76.3	66.5	66.3	65.3	59.5	58.4	54.3	66.4	63.2	50.1
Selective AI SD		18.1	15.7	14.8	12.4	12.6	12.5	15.0	14.6	17.9	20.5	12.5	15.1	22.0 ^c

^a Criterion Groups:

- | | |
|--|---|
| 1. AB43231 Reciprocating Engine Mechanic | 5. AB25231 Weather Observer |
| 2. AB46130 Munitions Specialist | 6. AB27231 Control Tower Operator |
| 3. AB64131 Organizational Supply Specialist | 7. AB30130 Aircraft Radio Repairman |
| 4. AB67130 Accounting and Finance Specialist | 8. AB32230 Fire Control System Mechanic |

^b Multiple correlation of the 15 variables within each criterion group

^c Distribution statistics for total sample are for General Aptitude Index.

schools was evaluated for the contribution of the composite based upon the eight schools pooled. The pair of Administrative schools were evaluated individually with the composite based upon them taken together.²

Review of the regression weights for each variable in the selected optimal-weighted composites suggested that only a few of the variables were contributing. If simple integer, or unit, weights were applied to these variables it might be possible to assemble a brief scale for inclusion in the Airman Qualifying Examination or for use as a separate pre-screen by recruiting personnel. To evaluate this possibility two simple sets of weights were devised, and the validity of the resulting composites was determined. The variables and weights applied in the four composites are listed in Table 2. The composite validities of the selected variables appear in Table 3.

TABLE 2. Regression Weights and Arbitrary Integral Weights Applied in the Derivation of the Composite Scores^a

No.	Variable Name	All Eight Schools			Administrative Schools		
		Beta Wt	B-Wt	Unit Wt	Beta Wt	B-Wt	Unit Wt
1	Cultural	-.07	-.25		-.06	-.25	
2	Domestic	-.05	-.27	-1	-.06	-.41	
3	Economic	.09	.26	1	.03	.11	
4	Educational Success	.24	1.06	4	.19	.98	1
5	Extroversion	-.04	-.15		.00	.00	
6	Itinerant	.00	.00		.06	.39	
7	Large Family	-.01	-.05		.03	.13	
8	Late Child	-.01	-.04		-.04	-.21	
9	Light Leisure	-.03	-.20		.02	.14	
10	Literary	-.02	-.06		-.03	-.12	
11	Parental Distance (BH)	-.07	-.43	-2	-.08	-.58	
12	Parental Distance (FB)	.01	.10		.10	.85	1
13	Reading	-.01	-.07		-.07	-.60	
14	Stenographic	.02	.22		.13	1.12	1
15	Urban	.03	.08		-.02	-.07	

^a The weights given are based upon the multiple regression of the 15 homogeneous scores against the final technical school grade for all eight of the technical schools pooled and the two administrative schools pooled, respectively. The unit weights represent a crude rounding of the largest B-weights in each set.

Although the composite validity of the 15 homogeneous scores is significant for each of the eight criteria, the nearly equivalent validity of the empirical composites based upon only a few variables emphasizes the contribution of the few scores. There is little difference in validity between the regression composite involving all 15 of the variables and the empirical composites of three or four variables. Such differences as do obtain are seen to be further reduced when the contribution of the composite to the operational selective aptitude index is inspected. The increases in predictive efficiency of the optimally weighted combination of composite and aptitude

² All data pertinent to derivation of the multiple correlations for each criterion group listed in Table 1 are available on request from the 6570th Personnel Research Laboratory (PRS), Lackland AFB, Texas.

TABLE 3. Validities and Contribution to Prediction of Final School Grade of Combinations of Homogeneous BI Scores and Aptitude Indexes

	Criterion Group							
	AB43231	AB46130	AB64131	AB67130	AB25231	AB27231	AB30130	AB32230
Validity of Selective Aptitude Index (SAI)	.52	.35	.41	.27	.49	.41	.60	.41
Validity of SAI + Composite of 15 ^a	.57	.40	.43	.33	.52	.44	.61	.42
Validity of SAI + Composite of 4 ^a	.56	.41	.42	.30	.51	.44	.61	.41
Validity of Composite of 15	.35	.24	.25	.27	.34	.27	.32	.23
Validity of Composite of 4	.31	.26	.23	.20	.33	.27	.29	.20
Validity of SAI + Admin Composite 15 ^a			.45	.38				
Validity of SAI + Admin Composite 3 ^a			.42	.34				
F ^d , Contribution of Comp 15 to SAI	52.25 ^b	26.22 ^b	10.91 ^b	9.88 ^b	36.98 ^b	17.52 ^b	15.21 ^b	9.76 ^b
F, Contribution of Comp 4 to SAI	41.99 ^b	36.50 ^b	6.46 ^c	3.82	28.86 ^b	18.87 ^b	13.14 ^b	3.12
F, Contribution of Admin Comp 15 to SAI			28.46 ^b	20.56 ^b				
F, Contribution of Admin Comp 3 to SAI			7.12 ^b	13.08 ^b				

^a Computed as 3-variable multiple correlation coefficients.

^b Significant beyond the 1% level.

^c Significant beyond the 5% level.

^d Computed by the formula:

$$F = \frac{R_f^2 - R_r^2}{1 - R_f^2} \cdot \frac{N - n_f - 1}{n_f - n_r}$$

where N = number of cases in sample

n_f = number of variables in full set of predictors (in this case, 2)

n_r = number of variables in restricted set of predictors (in this case, 1)

R_f^2 = squared multiple correlation of the full set of predictors with the criterion

R_r^2 = squared multiple correlation of the restricted set of predictors with the criterion

index over that of the aptitude index alone are small, but statistically significant. Data indicating the significance of the improvement in prediction by the combination of the composite with the aptitude index appear in Table 3. The joint validity of the selective aptitude index and the composite score of homogeneous biographical materials was determined through the multiple correlation of the two scores with the final school grade criterion.

Application of the 15-variable composite and 3-variable composite specifically developed for the Administrative aptitude area to the two samples of the study showed a substantial boost in validity for the combination of aptitude index and composite over that of the index alone, as reported in Table 3. However, this specific validity is insufficiently superior to that of the validity of the aptitude index plus the more general composite to justify development of a specific key or form of inventory for use in the Administrative area.

5. CONCLUSIONS

A few of the homogeneous scores, notably Educational Success, Economic Level and Parental Distance (Broken Home and Foreign Born) make significant contribution to the validity of the aptitude indexes as derived from Airman Classification Battery AC-2A. Drastically abbreviated composites with integer weights are as efficient as the full set of scores when added to the aptitude index. The small improvement in the validity coefficients is statistically significant.

Before applying the findings of this study, comparisons must be drawn between the situation at the time these data were collected, and the currently operational setting for application of Air Force selection and classification tests.

These data are based upon administration of Airman Classification Battery AC-2A, a full-day's testing including biographical information and aptitude tests, to enlisted personnel entering the Air Force in the period from January 1956 to February 1957. During the early months of 1956 the Air Force absorbed a large proportion of low-aptitude airmen. Data on the validation of the AC-2A classification battery across a wide range of Air Force specialties for men enlisting during the same calendar period reveal an average educational level of about 10.9 years, with a standard deviation of about 1.5 years.³ These data compare unfavorably with those for men recruited recently; since the latter portion of 1961 high school graduation has become virtually mandatory for Air Force enlistment.

It would seem that introduction of high school graduation as a prerequisite to Air Force enlistment would have the effect of introducing the content of the more valid homogeneous keys directly and indirectly into the selection process. If true, application of these scales to airmen who are all high school graduates would cause little improvement in selection beyond that provided by the aptitude indexes derived from the Airman Qualifying Examination.

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³ Unpublished Working Paper, "Airman Classification Battery AC-2A Validities," July 1959, available to qualified requesters from 6570th Personnel Research Laboratory (PRS), Lackland AFB, Texas.

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APPENDIX

DESCRIPTION OF HOMOGENEOUS SCORES DERIVED FROM AIRMAN CLASSIFICATION BATTERY AC-2A*

1. **Cultural.** The individual scoring high in this category will have done well in music and art in high school and fine arts and dramatics in college. He will have engaged in music, dancing, and dramatics in his leisure time.
2. **Domestic.** High scores on this scale will be achieved by individuals who have had hobbies or vocational experience in the areas of cooking, sewing, housework, or baby-sitting, or who have had domestic science courses in high school.
3. **Economic level** of the individual is scaled by the value of the parents' and the subject's personal property, the salary of the major wage earner in his home, and the purchase of specific magazines.
4. **Educational success** is concerned with educational level attained and achievement in various courses in high school and college.
5. **Extroversion** is related to frequent participation in group and individual sports. A high scoring subject in this category will indicate that he has considerable amount of leisure time filled with frequent participation in group and individual sports and other group activities.
6. **Itinerant.** A high score in this subtest is associated with a history of frequent changes in family residence and school systems. The father and mother will have been somewhat older than average parents at the birth of the subject and there may be a record of separation or divorce on the part of the parents. In addition, the parents typically are not home owners.
7. **Large Family.** Four or more persons including younger brothers and younger sisters will live in the home of a subject scoring high in this category. He will have spent considerable leisure time with his brothers and sisters, and he will not have had a personal room of his own when he went to high school. The father is typically a "laborer."
8. **Late Child** A subject will score high in this category if his parents were somewhat older than average parents at his birth, and if he has older brothers or sisters.
9. **Light Leisure** relates to such leisure time activities as listening to the radio and television, going to movies, and playing simple games.
10. **Literary.** This subscale is focussed on reasonably sophisticated reading tastes as revealed by a history of exposure to such magazines as Harpers Monthly, the Atlantic, the Saturday Review of Literature, Time, Newsweek, U.S. News and World Report, Better Homes and Gardens, scientific, educational or professional journals and trade or business publications.
11. **Parental Distance (Broken-Home).** Considers the psychological or geographic distance of the subject from one or both of his parents as a result of divorce or separation.
12. **Parental Distance (Foreign-Born).** Considers psychological or geographic distance of the subject from his parents as a function of their place of birth—whether United States or foreign, and whether the individual makes any financial contribution to his parents.
13. **Reading.** Concerns the extent of reading from elementary school age to the present, with the frequency of associated visits to libraries or to museums.

* A large portion of this appendix is excerpted from an unpublished staff research memorandum by Marvin H. Berkeley, "The development of homogeneous subtests of Biographical Inventory BE-CE601DX2," 19 August 1954.

14. **Stenographic.** This scale is concerned with experience in a clerical vocation, training in a commercial high school, and level of achievement in high school and college courses in the areas of bookkeeping, typing, or other commercial courses.

15. **Urban.** Relates to the size and the facilities in the home and the educational institutions of the individual.

6570th Personnel Research Laboratory (AMD), Lackland
AF Base, Tex.

Rpt No. PRL-TDR-62-12. PREDICTION OF TECHNICAL SCHOOL SUCCESS FROM HOMOGENEOUS BIOGRAPHICAL INVENTORY SCORES. Jul 62, iii + 9 p. Incl tables. Unclassified Report

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was found that prediction of training school grades was almost as good from a regression equation based on graduates from all 8 schools as from separate equations for schools in each job area. Composite scores combining the inventory scores and the aptitude index were significantly more valid than the aptitude indexes alone (average .43 vs .46); but a simplified combination of the 3 or 4 most valid inventory keys with the aptitude index proved equally valid. Under conditions existing at the time these data were collected, a short biographical inventory consisting of 4 or 5 of the homogeneous scales would add significantly to the validity of aptitude indexes derived from the last Airman Classification Battery.

1. Aptitude tests
2. Aviation personnel
3. Selection (personnel)
4. Mathematic prediction
5. Least squares method
- I. AFSC Project(Task) 7717(05)

- II. L. D. Brokaw
- III. Aval fr OTS
- IV. In ASTIA collection

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