DOCUMENT RESUME

ED 110 614 CE 004 386

AUTHOR	Mead, Michael A.
TITLE	RCMAT: A Computer Program to Calculate a Measure of Associative Verbal Relatedness. Interim Report. Occasional Paper No. 6.
INSTITUTION	Ohio State Univ., Columbus. Center for Vocational and Technical Education.
SPONS AGENCY	National Inst. of Education (DHEW), Washington, D.C.
PUB DATE	75
CONTRACT	NE-C-00-3-0078
NOTE	33p.; Best copy available, Appendixes A, B, and C may reproduce poorly
AVAILABLE FROM	The Center for Vocational Education, The Ohio State University, 1960 Kenny Road, Columbus, Ohio 43210 ($2.25)
EDRS PRICE	MF-$0.76 HC-$1.95 Plus Postage
DESCRIPTORS	*Association Tests; *Computer Programs; Psycholinguistics; *Verbal Stimuli
IDENTIFIERS	*RCMAT; Relatedness Coefficient Matrix Program

ABSTRACT

The report describes the characteristics and usage of a computer program, the Relatedness Coefficient Matrix Program (RCMAT), designed to summarize associative responses given to verbal stimuli by individual respondents and by groups of respondents. The computer program uses the response distributions for individuals, and the pooled response distributions for groups, to compute measures of associative relatedness between pairs of verbal stimuli. The program was written for an exploratory investigation of the use of word association procedures to assess the affective and descriptive meanings workers associate with their work environments. The RCMAT program is written in Fortran IV, level G. It calculates relatedness coefficients between all pairs of up to 100 stimulus words. Output is in the form of an S x S pair-wise matrix, where S is the number of stimulus words. Input consists of a problem card, a list of stimulus words, and each subject's response distribution for each stimulus word. Either individual or pooled relatedness coefficients may be calculated. Program listing, sample output data, and a bibliography are appended. (Author/JB)

Occasional Paper No. 6

RCMAT: A Computer Program to Calculate a Measure of Associative Verbal Relatedness

THE CENTER FOR VOCATIONAL EDUCATION
The Ohio State University • 1960 Kenny Road • Columbus, Ohio 43210

MISSION OF THE CENTER

The Center for Vocational Education's mission is to increase the ability of diverse agencies, institutions, and organizations to solve educational problems relating to individual career planning and preparation. The Center fulfills its mission by:

- Generating knowledge through research
- Developing educational programs and products
- Evaluating individual program needs and outcomes
- Installing educational programs and products
- Operating information systems and services
- Conducting leadership development and training programs

Occasional Paper No. 6

RCMAT: A COMPUTER PROGRAM TO CALCULATE A MEASURE OF ASSOCIATIVE VERBAL RELATEDNESS

Michael A. Mead

The Center for Vocational Education
The Ohio State University
Columbus, Ohio 43210

1975

An Interim Report
On a Project Conducted Under
Contract No. NE-C-00-3-0078

The material in this publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position or policy.

U.S. DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE

National Institute
of Education

FOREWORD

This report describes the characteristics and usage of a computer program designed to summarize associative responses given to verbal stimuli by individual respondents and by groups of respondents. The computer program uses the response distributions for individuals, and the pooled response distributions for groups to compute measures of associative relatedness between pairs of verbal stimuli.

The program was written for an exploratory investigation of the use of word association procedures to assess the affective and descriptive meanings workers associate with their work environments. This study was conducted as part of a long-range, programmatic research and development program at The Center, the purpose of which is to develop systematic guidelines and procedures for the derivation of curriculum content. Procedures and guidelines now under development by The Center's "Methods for Curriculum Content Derivation" program will aid developers of vocational curriculum and occupational training programs to accurately identify occupational requirements and to select curriculum content which most warrants formal training consideration.

It is hoped that this report, and the RCMAT computer program, will be useful to research and development specialists in education, business, industry, and government to faciliate further application and development of word association procedures to the problems of better understanding cognitive and affective processes.

The Center is indebted to the author, Michael Mead, research technician at The Center, for his development of the program and the report. The Center also expresses its appreciation to Cheng Liu and Duane Essex whose work in the research and development program initiated and guided the development and use of the computer program.

Robert E. Taylor
Director
The Center for Vocational Education

TABLE OF CONTENTS

LIST OF FIGURES

ERRATA

The following corrections to the text should be noted:

Page 6, paragraph 1, lines 9-12 -- Should be:

> ...order indices for A and B respectively would be 3 + 2 = 5 and 5 + 4 = 9. Response A would, therefore, appear in the pooled response distribution before response B, since A has the lower order index.

Page 10, Column 18, Punch 1 -- 71-80 should be 73-80.

Page 12, paragraph 2, line 10 -- exhause should be exhaust.

In Appendix B, the last line on page 21 accompanies the matrix at the top of page 22.

INTRODUCTION

Background

The computer program described here was developed to help meet the needs of a series of exploratory methodological studies conducted at The Center for Vocational Education, The Ohio State University (Essex & Liu, 1974). These studies were related to an earlier series of methodological studies conducted by the Minnesota Research Coordinating Unit for Vocational Education at the University of Minnesota (Moss et al., 1968; Smith, 1968; Pratzner, 1969).

All of these studies are concerned with the development and use of word association procedures to obtain self-reports from workers on various aspects of their work. The Minnesota studies centered on the development of word association procedures for use in identifying and comparing the meanings and structure of meanings that workers associate with important technical concepts in their occupation. The Center's studies used many of the same word association procedures, but focused on their adoption and use for identifying and comparing the affective meanings (i.e., attitudes and feelings) that workers associate with a variety of non-technical aspects of their work environments (e.g., hours of work, pay, opportunities for self-fulfillment, supervision). Underlying all of these efforts was the assumption that knowledge of the relevant cognitive and affective content of occupations, along with accurate and timely information about relevant job performance, would be useful in deriving critical content for occupational training programs.

One of the most important methodological similarities among the studies was their use of the Relatedness Coefficient (RC) statistic developed by Garskof and Houston (1963). The RC statistic was used to compute a measure of relatedness between pairs of verbal stimuli using the pooled distribution of responses given by groups of workers to the stimuli. The Minnesota investigators developed a method to manually construct pooled associative response distributions and a computer program to calculate RC's from the pooled response distributions. However, the use of this computer program was cumbersome and time consuming, requiring extensive manual tabulation and complex coding schemes of group response data prior to computerization. It will be obvious from the examples of word association data presented in the following sections that even a small sample of subjects responding for very short intervals to just a few stimuli can rapidly generate substantial amounts of associative response data. Thus, the need for an efficient automated method requiring a minimum of preprocessing of response data was apparent, and the Relatedness Coefficient Matrix Program (RCMAT) was developed for use in The Center studies.

Word Association Procedures

Word association procedures have a long history of development. A variety of techniques are available and investigation still continues.

In most approaches to word associations, the meaning of a word is identified by the words it elicits when it is used as a stimulus in a free association task. The overlap in the responses elicited by two stimulus words is used as an indication of the degree of similarity or relatedness between the words and their meanings.

The associative meanings of words used as stimuli are usually obtained by two basically different response modes. In single response free association tasks, each subject is restricted to only one response per stimulus word. While this single response is considered to represent the most salient meaning of the stimulus for each subject, large samples of subjects are required to identify the group meaning of the stimulus.

In multiple response free association tasks, the meaning of stimulus words and the relatedness between two words is estimated using the distribution of all response words each subject associates with the stimulus words. Subjects are instructed to chain respond (continuous free association) to the stimulus, or to respond to numerous repetitions of a stimulus word) (continued free association). In both instances, individual response distributions to two or more stimulus words are then compared to obtain a measure of relatedness in meaning between the selected stimuli.

Essentially the same continued word association procedures were used for the series of studies conducted at the University of Minnesota and at The Center. Samples of workers were presented with word association booklets. The total number of pages in the booklet corresponded to the number of stimulus words in the total stimulus word list. Each page of the booklet contained numerous repetitions of a single stimulus word, each repetition of the word was followed by a blank line. Subjects were instructed to read the stimulus word each time they responded and to write as many different words in the blanks provided as the stimulus word brought to mind. The maximum amount of time to respond to each stimulus word varied among the several studies ranging from 45 seconds to one minute per stimulus word.

The Relatedness Coefficient

A variety of techniques are available to measure the degree of similarity or relatedness in the meanings of stimulus words generated by such word association procedures.[1] Garskof and Houston (1963) defined the associative meaning of a stimulus word as the ordered set of associates given by an individual in response to a stimulus word. Further, they defined the relatedness of two stimulus words as a function of the degree to whic their respective meanings intersected or overlapped. The Relatedness Coefficient (RC) was developed as a measure of the degree of similarity in the meanings of stimulus words.

Relatedness coefficients for individual subjects. The RC statistic was first proposed as a measure of the overlap in associative meaning of two stimulus words for an individual respondent. Responses to the two stimulus words between which an RC was to be calculated were listed in the order in which they were emitted with the stimulus word itself listed as the first response. If the longer of two response lists given by an individual to two stimulus words contained X response words, the stimulus word was assigned rank X. The second word in each list was assigned rank X-1 and so forth until all responses in each list were assigned a rank. Figure 1 is an example of two rank ordered response lists.

Stimulus Word STREET		Stimulus Word ADDRESS	
Response	Rank	Response	Rank
STREET	6	ADDRESS	6
ROAD	5	STREET	5
CITY	4	CITY	4
ADDRESS	3	TOWN	3
AVENUE	2	ZIP CODE	2

Figure 1. Rank Ordered Response List for Two Stimulus Words.

Szalay and Brent (1967), among others, support this ranking scheme with the contention that the sequence or order in which response words are emitted reflects the rank order of response salience or importance. Response words emitted first are the most salient parts of the meaning of the stimulus

[1] In particular, the reports by Deese (1962), Johnson and Collier (1969), and Garskof and Houston (1963) include comparisons and discussions of alternative measures and indices of associative relatedness.

word, while those responses emitted later are less salient parts of the meaning. Moreover, the stimulus word itself is considered to be the first response in the sequence of responses.

One table can be constructed of the words in common to the response lists (for the two stimulus words). The common response words are listed with the ranks they hold in each response list as shown in Figure 2.

	Rank in STREET	Rank in ADDRESS
Response	Response List	Response List
STREET	6	5
ADDRESS	3	6
CITY	4	4

Figure 2. Rank Order of Common Responses to the Two Stimulus Words.

The relatedness coefficient (RC) is computed as follows:

$$RC_{ij} = \frac{\sum_{m=1}^{k} R_{mi} \cdot R_{mj}}{\sum_{m=1}^{x} m^2 - \left[X^p - (X-1)^p\right]^2}$$

where RC_{ij} = Relatedness coefficient between stimulus words i and j.

R_{mi} = Rank the m^{th} response in the common table holds in the response list for stimulus word i.

R_{mj} = Rank the m^{th} response in the common table holds in the response list for stimulus word j.

k = number of responses in common.

X = number of responses in longer response list.

p = a constant ≥ 0, typically equal to 1. For further discussion see Garskof and Houston (1963), and Deese (1965).

The numerator represents the overlap between stimuli and the summation in the denominator represents the maximum possible overlap if each response occurred in both lists in the same order. The term in brackets is a correction term (see Garskof & Houston, 1963). The size of the relatedness coefficient is directly proportional to the degree of similarity in the meanings of two stimulus words. An RC of .00 means no associative relatedness between two stimulus words and an RC of 1.00 indicates that the associative meanings of two words are identical.

For the example shown in Figure 2, the relatedness coefficient is computed as follows:

$$RC_{Street/Address} = \frac{6 \cdot 5 + 3 \cdot 6 + 4 \cdot 4}{1^2 + 2^2 + 3^2 + 4^2 + 5^2 + 6^2 - 1^2}$$

$$RC = .711 \quad \text{(for p=1)}$$

The computation of individual RC's as shown above facilitates the study of similarities and differences in associative meaning for individual respondents. The individual form of RC makes efficient use of the order of emission of responses. This characteristic of the measure distinguishes it from other proposed overlap measures which consider only number of responses or frequency of common responses (see Cramer, 1968; Marshall & Cofer, 1963). Individual RC's may be averaged to obtain a summary measure over all subjects under study.

Pooled relatedness coefficients for groups. The group summary measure obtained by computing mean RC's should not be confused with the pooled RC computed on the basis of pooled response distributions. The pooling procedure for group data developed by the Minnesota investigators and used throughout the Minnesota and Center studies facilitates the study of group associations and relatedness.

Responses given by all subjects to a particular stimulus word are pooled into a single response list. This list of responses is ordered by the number of subjects emitting each response. The response with the highest frequency is listed first with other responses listed in descending order of frequency of emission. If two or more responses have tied frequencies, order of placement within that frequency is determined by the order in which the responses were emitted. For example, if both response A and response B had a frequency of 2 where one subject gave response A as the third response and B as the fifth response, and a second subject gave response A as the second response and B as the fourth response, the order indicies for A and B respectively would be 3 + 5 = 8 and 2 + 4 = 6. Response B would, therefore, appear in the pooled response distribution before response A, since B has the lower order index.

Once pooled response distributions have been compiled and ordered for each of the two stimulus words whose relatedness is to be examined, the lists can be ranked in the same manner as the lists for individual RC's, with the first word in each response list having rank X, where X represents the number of words in the longer list. If two responses in a particular pooled list have exactly the same frequency and order index, the average of the ranks that would ordinarily be assigned, is assigned to each of the tied responses. Figure 3 shows an example of pooled response distributions for two stimulus words.

Stimulus Word STREET				Stimulus Word ADDRESS			
Response	Freq.	Order	Rank	Response	Freq.	Order	Rank
STREET	5	5	6	ADDRESS	5	5	6
ADDRESS	4	8	5	STREET	4	9	5
CITY	4	12	4	CITY	3	11	3.5
ROAD	3	6	3	TOWN	3	11	3.5
AVENUE	2	10	2	ZIP CODE	1	4	2
				NUMBER	1	6	1

Figure 3. Pooled Response Distributions for Two Stimulus Words.

Common words in the pooled response distributions for the two stimulus words can be identified and listed with the ranks they hold in each pooled response distribution (Figure 4).

	Rank in STREET	Rank in ADDRESS
Response	Response list	Response list
STREET	6	5
ADDRESS	5	6
CITY	4	3.5

Figure 4. Rank Order of Common Responses in the Pooled Response Distributions.

RC for groups is then computed using these ranks in exactly the same way as for the individual form of RC. For example, the pooled RC is:

$$\text{POOLED RC}_{\text{Street/Address}} = \frac{6 \cdot 5 + 5 \cdot 6 + 4 \cdot 3.5}{1^2 + 2^2 + 3^2 + 4^2 + 5^2 + 6^2 - 1^2}$$

$$= .822$$

It should be noted that each form of RC has its own uses. The individual form of RC facilitates the study of individual similarities and differences in associative meaning. The pooling procedure for group data, and the pooled RC measure, facilitate the study of group associative meaning. Szalay, Brent, and Lysne (1968) suggested that the reliability of associative responses are high for groups while low for individuals. This is due, in part, to the fact that group data includes a larger number of responses than individual response data. In terms of RC, responses emitted by a large number of subjects have a high frequency and, therefore, a greater weight in the calculation of relatedness. This source of stability is not applicable to the individual form. In addition, responses which are common to two stimulus words but emitted by different subjects are excluded in the calculation of individual RC's, while the pooled RC includes this source of commonality. For this reason alone, pooled RC can usually be expected to be higher than the mean of individual RC's. The "order of emission" information considered by the individual form is, however, all but lost in the pooled form of RC, since ranks in the pooled response list are assigned on the basis of frequency. Only in the case of tied frequencies is order of emission taken into account. Some frequency information is also lost in that the assigned rank does not indicate the actual frequency of occurrence, only the rank order of the frequency with which each response was emitted.

THE RCMAT PROGRAM

General Characteristics

The RCMAT program calculates relatedness coefficients between all pairs of up to 100 stimulus words. Output is in the form of an S X S pair-wise matrix where S is the numoer of stimulus words. Input consists of a problem card, a list of stimulus words, and each subject's response distribution for each stimulus word. Either individual or pooled RC's may be calculated.

The program is written in FORTRAN IV, level G, for the IBM 370/165, but could run under any FORTRAN IV compiler. Currently dimensioned for 100 stimulus words with up to 1000 unique responses per stimulus, the program will execute in approximately 190 K, with execution time usually less than five minutes. Dimensions can easily be increased, to allow for a larger number of stimulus words or responses, or decreased to conserve core (100 stimulus words, 5000 responses per stimulus increases region required to 350 K). The program calls a temporary tape or disk data set located on FORTRAN logical Unit 1, and any punched output requested will be written to Unit 7. Reader and printer are Units 5 and 6, respectively. The complete program listing has been included in Appendix A.

Program Input

The input requirements for the RCMAT program are shown in Figure 5, along with the order and format of the problem, stimulus word, and response data cards. Several features of the program input warrant additional comment. One of those features is the provision of the option to run several problems in a single submission of the program. The program is capable of handling any combination of the following problems:

1. Computing individual RC matrices for one or more different samples of subjects,

2. Computing individual RC matrices for one or more different sets of stimulus words,

3. Computing a pooled RC matrix for one or more different samples of subjects, and

(1) System Cards
(2) Source Deck
(3) Problem Card

Column	Use
1-5	Number of stimulus words
6	Type of problem and output 1 = Pooled RC's desired 2 = Individual RC's desired
7-11	If pooled RC's are desired (i.e., Column 6 = 1), enter the frequency of response below which responses will not be included in the analysis
12	Punch pooled RC matrix 0 = No, do not punch pooled RC matrix, Column 6 = 2 1 = Yes, punch pooled RC matrix, Column 6 = 1
APPLICABLE ONLY IF INDIVIDUAL RC MATRICES REQUESTED	
13	Print individual RC matrices 0 = No 1 = Yes
14	Punch individual RC matrices 0 = No 1 = Yes
15	Matrix of means of individual RC's desired 0 = No 1 = Yes
16	Print mean RC matrix 0 = No 1 = Yes (Column 15 must = 1)
17	Punch mean RC matrix 0 = No 1 = Yes (Column 15 must = 1)
18	If there is punched output. manner in which RC matrix is to be punched: 0 = Continue new row of matrix on same card. 1 = New row of matrix begins new card (This mode has the advantage that cards can be sequentially numbered in Columns 71-80)
19-21	Number of subjects
22	Another problem follows 0 = No 1 = Yes

(4) Stimulus Word Cards (Up to 25 cards for a total of 100 stimulus words)

Column	Use
1-18	First stimulus word (left-justified)
19-36	Second stimulus word (left-justified)
37-54	Third stimulus word (left-justified)
55-72	Fourth stimulus word (left-justified)

(5) Data Cards

First data card:

Column	Use
1-18	Blank (Indicates beginning of data for a new subject or new stimulus word)
19-36	Stimulus word (left-justified)
37-54	First response word in the order emitted by subject (left-justified)
55-72	Second response word in the order emitted by subject (left-justified)

Second and all subsequent data cards:

All four fields of as many cards as necessary to exhaust all responses to the stimulus word by a subject; all responses left-justified; unused fields on last card must be blank

(6) Blank Card

Figure 5 - Program Input

4. Computing a pooled RC matrix for one or more different sets of stimulus words.

Thus, for example, a single program could be set up to first compute individual RC matrices for one sample of subjects and then to compute a pooled RC matrix for a different sample of subjects and a different set of stimulus words.

This particular feature makes the use of the program convenient and highly flexible. To exercise this program option, a "1" in Column 22 on the first problem card indicates that a second problem card will follow the stimulus word cards, data cards, and the blank card ending the first problem. The second set of stimulus word cards, data cards, and a blank card for the second problem then follows the second problem card. If a third problem is to follow, a "1" is entered in Column 22 of the second problem card and the card deck is ordered as it is for the first and second problems.

Another important feature of the program is applicable to the computation of pooled RC's. The program provides the option to include all responses or to restrict the number of responses to be included in the pooled response distributions and used to compute a pooled RC matrix. While this option may have other uses, it was included so that idiosyncratic responses (i.e., responses given to a stimulus word by only one subject in a sample) could be eliminated from the pooled response distributions for stimulus words. To use this option, the frequency of response below which responses will not be included in the analysis is entered in Columns 7-11 on the problem card (see Figure 5).

<u>Stimulus word cards</u>. The RCMAT program was designed to accomodate up to 100 stimulus words. Stimulus words are punched four to a card in four fields of 18 columns each. Each stimulus word must be left-justified within a field (see Figure 5).

Perhaps the most important consideration in the preparation of stimulus word input is the order in which stimulus words are punched. Stimulus words must appear on stimulus word cards in exactly the same order as they do on data cards. It is often most convenient to punch stimulus word and response data directly from the subjects' response booklets since this usually does not require preprocessing or coding of response data. However, this procedure deserves a special note of caution. If the stimulus word order was not the same in all response booklets (e.g., if, as is often the case, response booklets contain one or more random orders of pages/stimulus words), it would be necessary to separate the booklets and arrange all stimulus words in exactly the same order prior to preparing the stimulus word and data cards.

Data cards. As shown in Figure 5, each data card consists of four fields composed of Columns 1-18, 19-36, 37-54, and 55-72. A blank first field is used to indicate the beginning of the data for a new subject or new stimulus word. One subject's data for one stimulus word consists of a first card with Columns 1-18 blank; the stimulus word, left-justified in Columns 19-36; and the subject's responses to that stimulus (in the order emitted) in the remaining two fields of the first card. All four fields of as many subsequent cards as are necessary are used to exhause all responses to the stimulus word by that subject. If the last of these cards does not contain responses in all four fields, the unused fields must be blank. The RCMAT program is capable of handling up to 1000 unique response words per stimulus word.

To compute pooled RC's, all subjects' data for the first stimulus word must be together, followed by subjects' data for the second stimulus word, and so on for each stimulus word in the set. To compute RC's for individual subjects, all data for the first subject on all stimulus words must be together, followed by all data for the second subject on all stimulus words, and so on for each subject in the sample.

The last eight columns of the data cards are not used to record subjects' responses. These columns (Columns 73-80) of the data cards may be left blank or in many cases they may be used in the following way:

Column	Use
73-75	Stimulus word identification number
76-78	Subject identification number
79-80	Card number for that subject on that stimulus word

Indexing data cards in this way uniquely identifies the cards. A card sort on Columns 80, 79, 78, ..., 73 will put the cards in proper order for computing pooled RC's, while a sort on Columns 80, 79, 75, 74, 73, 78, 77, 76 will put the cards in proper order for computing individual RC's.

Program Output

Output for individual subjects. An example of the output data for individual subjects has been included in Appendix B. In this example, five subjects responded to five stimulus words. When RC's are computed for individual subjects, three types of output can be obtained:

1. A list of the stimulus words with corresponding numbers identifying their column and row positions in the RC matrices;

2. One RC matrix for each subject in the sample (printed and/or punched for reference or further analysis);

3. A mean RC matrix whose elements are the means of the respective elements of all the individual matrices (printed and/or punched).

Output for pooled RC's. An example of the output data for pooled RC's has been included in Appendix C. In this example, pooled RC output is shown for the same five subjects and the same five stimulus words used to illustrate the output for individual subjects.

When pooled RC output is requested, three types of output are obtained:

1. Response lists from all subjects are pooled and ranked within the program and the pooled response distributions for each stimulus word is printed along with the frequency, order, and rank of each response word in the pooled response distribution;

2. A list of the stimulus words with corresponding numbers identifying their column and row positions in the pooled RC matrix;

3. One pooled RC matrix for the total sample of subjects (printed, and/or punched).

Possible Errors

Two of the most common errors which occur in the use of the RCMAT program are identified and explained below.

End of file on Unit 1. This error can only occur when the stimulus word itself is not listed as each subject's first response to each stimulus word. Columns 19-36 of each subject's first data card for a stimulus word must contain the stimulus word itself and this data card must be present for each subject whether or not any additional responses were given by the subject.

End of file on Unit 5. This error can occur for several reasons. It can occur when there are not NNS X NOSJ + 1 data cards with the first field (Columns 1-18) blank (where NNS = the number of stimulus words, and NOSJ = the number of subjects). This could mean that:

1. In the case of the pooled RC, at least one subject was left out of a stimulus word sub-deck.

2. In case of the individual RC, data for at least one stimulus word was left out of the subject sub-deck.

3. In either case, the blank card following the data cards may have been omitted.

This particular error can also occur when one or more of the stimulus word cards are missing. Or, it could occur when there are errors in the information contained on the problem card (i.e., the number of stimulus words shown in Columns 1-5 does not match the number of stimulus word cards or, the number of subjects shown in Columns 19-21 does not match the number of subjects included in the data card subdeck).

APPENDIX A

Program Listing: RCMAT, Relatedness Coefficient Matrix Program

```
      REAL KOMMON,NUMER,LOWER
      DIMENSION RESP(2,1000,7), X(4,5), RC(100,100), KOMMON(1000,2), NRE
     1S(100), STIM(100,5), RCSUM(100,100), FORM(9), DUMNUM(10), DUMDUM(1
     20)
      DIMENSION DUMRNK(1000)
      DATA BLANK/4H    /
      DATA FORM/1H(,2H10,1HF,1H7,2H.5,1H,,1H1,4HX,I9,1H)/,DUMNUM/1H1,1H2
     1,1H3,1H4,1H5,1H6,1H7,1H8,1H9,2H10/,DUMDUM/2H64,2H57,2H50,2H43,2H36
     2,2H29,2H22,2H15,1H8,1H1/
      IPROB=0
    1 READ (5,91) NNS,NOP1,FREMIN,NOP2,NOP3,NOP4,NOP5,NOP6,NOP7,MODOPT,N
     1OSJ,IAP
      IPROB=IPROB+1
      WRITE (6,103) IPROB
      IF(NNS.EQ.0) GO TO 1
      IF(NOP1.EQ.1) GO TO 3
      DO 2 I=1,100
      DO 2 J=1,100
    2 RCSUM(I,J)=0.0
    3 READ (5,92) ((STIM(I,J),J=1,5),I=1,NNS)
      NOPE=0
      DO 87 ITCH=1,NOSJ
      NS=1
      I=0
      IT=0
      REWIND 1
      IF(NOP1.EQ.2.AND.ITCH.GT.1) GO TO 4
      READ (5,92) ((X(J,K),K=1,5),J=1,4)
      NOSRD=1
    4 I=I+1
      IT=IT+1
      DO 5 J=1,5
    5 RESP(1,I,J)=X(2,J)
      RESP(1,I,6)=1.
      RESP(1,I,7)=FLOAT(I)
      IF(X(3,1).EQ.BLANK) GO TO 8
      I=I+1
      IT=IT+1
      DO 6 J=1,5
    6 RESP(1,I,J)=X(3,J)
      RESP(1,I,6)=1.
      RESP(1,I,7)=FLOAT(I)
      IF(X(4,1).EQ.BLANK) GO TO 8
      I=I+1
      IT=IT+1
      DO 7 J=1,5
    7 RESP(1,I,J)=X(4,J)
      RESP(1,I,6)=1.
      RESP(1,I,7)=FLOAT(I)
    8 READ (5,92) ((X(J,K),K=1,5),J=1,4)
      IF(X(1,1).EQ.BLANK) GO TO 10
      I=I+1
      IT=IT+1
      DO 9 J=1,5
    9 RESP(1,I,J)=X(1,J)
```

22

```
      RESP(1,I,6)=1.
      RESP(1,I,7)=FLOAT(I)
      IF(X(2,1).EQ.BLANK) GO TO 8
      GO TO 4
   10 IF(NOP1.EQ.2) GO TO 40
      IF(NOSRD.EQ.NOSJ) GO TO 40
      NOSRD=NOSRD+1
      I=1
   11 DO 13 J=1,IT
      IF(X(2,1).EQ.RESP(1,J,1).AND.X(2,2).EQ.RESP(1,J,2).AND.X(2,3).EQ.R
     1ESP(1,J,3).AND.X(2,4).EQ.RESP(1,J,4).AND.X(2,5).EQ.RESP(1,J,5)) GO
     2 TO 12
      K=0
      GO TO 13
   12 K=J
      J=IT
   13 CONTINUE
      IF(K) 14,14,16
   14 IT=IT+1
      DO 15 J=1,5
   15 RESP(1,IT,J)=X(2,J)
      RESP(1,IT,6)=1.
      RESP(1,IT,7)=FLOAT(I)
      GO TO 17
   16 RESP(1,K,6)=RESP(1,K,6)+1.
      RESP(1,K,7)=RESP(1,K,7)+FLOAT(I)
   17 IF(X(3,1).NE.BLANK) GO TO 19
   18 READ (5,92) ((X(J,K),K=1,5),J=1,4)
      GO TO 10
   19 I=I+1
      DO 21 J=1,IT
      IF(X(3,1).EQ.RESP(1,J,1).AND.X(3,2).EQ.RESP(1,J,2).AND.X(3,3).EQ.R
     1ESP(1,J,3).AND.X(3,4).EQ.RESP(1,J,4).AND.X(3,5).EQ.RESP(1,J,5)) GO
     2 TO 20
      K=0
      GO TO 21
   20 K=J
      J=IT
   21 CONTINUE
      IF(K) 22,22,24
   22 IT=IT+1
      DO 23 J=1,5
   23 RESP(1,IT,J)=X(3,J)
      RESP(1,IT,6)=1.
      RESP(1,IT,7)=FLOAT(I)
      GO TO 25
   24 RESP(1,K,6)=RESP(1,K,6)+1.
      RESP(1,K,7)=RESP(1,K,7)+FLOAT(I)
   25 IF(X(4,1).NE.BLANK) GO TO 26
      GO TO 18
   26 I=I+1
      DO 28 J=1,IT
      IF(X(4,1).EQ.RESP(1,J,1).AND.X(4,2).EQ.RESP(1,J,2).AND.X(4,3).EQ.R
     1ESP(1,J,3).AND.X(4,4).EQ.RESP(1,J,4).AND.X(3,5).EQ.RESP(1,J,5)) GO
     2 TO 27
```

```
      K=0
      GO TO 28
7     K=J
      J=IT
8     CONTINUE
      IF(K) 29,29,31
9     IT=IT+1
      DO 30 J=1,5
0     RESP(1,IT,J)=X(4,J)
      RESP(1,IT,6)=1.
      RESP(1,IT,7)=FLOAT(I)
      GO TO 32
1     RESP(1,K,6)=RESP(1,K,6)+1.
      RESP(1,K,7)=RESP(1,K,7)+FLOAT(I)
2     READ (5,92) ((X(J,K),K=1,5),J=1,4)
      IF(X(1,1).EQ.BLANK) GO TO 16
      I=I+1
      DO 34 J=1,IT
      IF(X(1,1).EQ.RESP(1,J,1).AND.X(1,2).EQ.RESP(1,J,2).AND.X(1,3).EQ.R
     1ESP(1,J,3).AND.X(4,4).EQ.RESP(1,J,4).AND.X(3,5).EQ.RESP(1,J,5)) GO
     2 TO 33
      K=0
      GO TO 34
3     K=J
      J=IT
4     CONTINUE
      IF(K) 35,35,37
5     IT=IT+1
      DO 36 J=1,5
6     RESP(1,IT,J)=X(1,J)
      RESP(1,IT,6)=1.
      RESP(1,IT,7)=FLOAT(I)
      GO TO 38
7     RESP(1,K,6)=RESP(1,K,6)+1.
      RESP(1,K,7)=RESP(1,K,7)+FLOAT(I)
8     IF(X(2,1).NE.BLANK) GO TO 39
      GO TO 18
9     I=I+1
      GO TO 11
0     NRES(NS)=IT
      IF(NOPI.EQ.1) GO TO 42
      DO 41 KG=1,IT
1     WRITE (1,93) (RESP(1,KG,J),J=1,7)
      GO TO 59
2     WRITE (6,94) (STIM(NS,KG),KG=1,5)
      KQ=0
3     XMAX=0
      I=1
4     IF(RESP(1,I,6).GT.XMAX) GO TO 46
5     IF(I.EQ.NRES(NS)) GO TO 50
      I=I+1
      GO TO 44
6     IF(RESP(1,I,6).EQ.XMAX) GO TO 48
       X=RESP(1,I,6)
       SUB=I
```

```
47    IF(I.EQ.NRES(NS)) GO TO 50
      I=I+1
      GO TO 44
48    IF(RESP(1,I,7).LT.RESP(1,MAXSUB,7)) GO TO 49
      GO TO 45
49    MAXSUB=I
      GO TO 47
50    IF(RESP(1,MAXSUB,6).LT.FREMIN) GO TO 52
      KQ=KQ+1
      DO 51 J=1,7
51    RESP(2,KQ,J)=RESP(1,MAXSUB,J)
      RESP(1,MAXSUB,6)=-1.0
      IF(KQ.LT.NRES(NS)) GO TO 43
      GO TO 53
52    NRES(NS)=KQ
53    IDUM=NRES(NS)
      DO 54 KQ=1,IDUM
54    DUMRNK(KQ)=FLOAT(KQ)
      KQRK=0
      IDUM=NRES(NS)-1
      DO 57 J=1,IDUM
      KQ=J+1
      IF(RESP(2,J,6).EQ.RESP(2,KQ,6).AND.RESP(2,J,7).EQ.RESP(2,KQ,7)) GO
     1 TO 55
      KQRK=0
      GO TO 57
55    KQRK=KQRK+1
      TMPRNK=(FLOAT(KQRK)*DUMRNK(J)+FLOAT(KQ))/FLOAT(KQRK+1)
      IJJJ=KQ-KQRK
      DO 56 I=IJJJ,KQ
56    DUMRNK(I)=TMPRNK
57    CONTINUE
      IDUM=NRES(NS)
      DO 58 I=1,IDUM
      WRITE (1,93) (RESP(2,I,J),J=1,6),DUMRNK(I)
58    WRITE (6,95) (RESP(2,I,J),J=1,7),DUMRNK(I)
59    IF(NS.EQ.NNS) GO TO 60
      NS=NS+1
      NOSPD=1
      I=0
      II=0
      GO TO 4
60    IPLACE=2
      IF(NOP1-1) 59,61,63
61    DO 62 J=1,IDUM
62    RESP(2,J,7)=DUMRNK(J)
      GO TO 65
63    DO 64 ISUB=1,II
      DO 64 J=1,7
64    RESP(2,ISUB,J)=RESP(1,ISUB,J)
65    NNNS=NNS+2
      DO 74 ISUB=2,NNS
      I=NNNS-ISUB
      K=I-1
      IPLACE=3-IPLACE
```

```
      IF(IPLACE.EQ.1) M=NRES(I)
      IF(IPLACE.EQ.2) L=NRES(I)
      REWIND 1
      DO 74 J=1,K
      IF(IPLACE.EQ.1) L=NRES(J)
      IF(IPLACE.EQ.2) M=NRES(J)
      KSUB=NRES(J)
      DO 66 LSUB=1,KSUB
66    READ (1,93) (RESP(IPLACE,LSUB,JXXX),JXXX=1,7)
      KN=0
      INDEX=1+MAX0(L,M)
      ANDEX=FLOAT(INDEX)
      DO 70 N=1,L
      DO 68 NN=1,M
      IF(RESP(1,N,1).EQ.RESP(2,NN,1).AND.RESP(1,N,2).EQ.RESP(2,NN,2).AND
     1.RESP(1,N,3).EQ.RESP(2,NN,3).AND.RESP(1,N,4).EQ.RESP(2,NN,4).AND.R
     2ESP(1,N,5).EQ.RESP(2,NN,5)) GO TO 67
      KZ=0
      GO TO 68
67    KZ=NN
      NN=M
68    CONTINUE
      IF(KZ) 70,70,69
69    KN=KN+1
      KOMMON(KN,1)=ANDEX-RESP(1,N,7)
      KOMMON(KN,2)=ANDEX-RESP(2,KZ,7)
70    CONTINUE
      NUMER=0.
      LOWER=0.
      IF(KN.NE.0) GO TO 71
      RC(I,J)=0.
      GO TO 74
71    INDEX=INDEX-1
      DO 72 N=1,INDEX
72    LOWER=LOWER+FLOAT(N**2)
      DO 73 N=1,KN
73    NUMER=NUMER+KOMMON(N,1)*KOMMON(N,2)
      RC(I,J)=NUMER/(LOWER-1.0)
74    RC(J,I)=RC(I,J)
      DO 75 I=1,NNS
75    RC(I,I)=1.0
76    IF(NOP1.EQ.2.AND.NOP4.EQ.0) GO TO 80
      IF(NOP1.EQ.1.AND.NOP2.EQ.0) GO TO 80
      IF(MODOPT) 78,77,78
77    WRITE (7,96) ((RC(I,J),J=1,NNS),I=1,NNS)
      GO TO 80
78    N=0
      DO 79 J=1,NNS
      DO 79 I=1,NNS,10
      M=I+9
      L=MIN0(M,NNS)
      IXNAY=L-I+1
      FORM(2)=DUMNUM(IXNAY)
      FORM(7)=DUMDUM(IXNAY)
      N=N+1
```

```
79    WRITE (7,FORM) (RC(J,K),K=1,L),N
80    IF(NOP1.EQ.2.AND.NOP3.EQ.0) GO TO 84
      IF(NOP1.EQ.2.AND.ITCH.GT.1) GO TO 82
      WRITE (6,99)
      DO 81 I=1,NNS
81    WRITE (6,100) (STIM(I,J),J=1,5),I
82    WRITE (6,101)
      IF(NOP1.EQ.2.AND.NOP8.EQ.0) WRITE (6,102) ITCH
      DO 83 I=1,NNS,20
      M=I+19
      L=MINO(M,NNS)
      WRITE (6,97) (K,K=I,L)
      DO 83 J=1,NNS
83    WRITE (6,98) J,(RC(J,K),K=I,L)
84    IF(NOP1.EQ.1.OR.NOP5.EQ.0) GO TO 86
      DO 85 I=1,NNS
      DO 85 J=1,NNS
85    RCSUM(I,J)=RCSUM(I,J)+RC(I,J)
      GO TO 87
86    IF(NOP1.EQ.1) ITCH=NOSJ
87    CONTINUE
      IF(NOP1.EQ.1.OR.NOP5.EQ.0) GO TO 89
      DO 88 I=1,NNS
      DO 88 J=1,NNS
88    RC(I,J)=RCSUM(I,J)/FLOAT(NOSJ)
      NOP3=NOP6
      NOP4=NOP7
      NOP5=0
      NOP8=1
      GO TO 76
89    IF(IAP.NE.1) STOP
      IF(NOP1.EQ.1) GO TO 1
      DO 90 I=1,NNS
      DO 90 J=1,NNS
90    RCSUM(I,J)=0.0
      GO TO 1
C
91    FORMAT (I5,I1,F5.0,7I1,I3,I1)
92    FORMAT (4(4A4,A2))
93    FORMAT (4A4,A2,2F6.2)
94    FORMAT (//1X,'RESPONSES TO STIMULUS WORD :',3X,4A4,A2,10X,'FREQ',1
     10X,'ORDER',10X,'RANK')
95    FORMAT (32X,4A4,A2,9X,F6.0,8X,F6.0,8X,F8.2)
96    FORMAT (10F7.4)
97    FORMAT (///6X,20(I5,1X)/)
98    FORMAT (1X,I4,1X,20(F5.3,1X))
99    FORMAT (1H1,'STIMULUS WORD',10X,'CODE NO.'//)
100   FORMAT (1X,4A4,A2,7X,I3)
101   FORMAT (////1X,'RC MATRIX')
102   FORMAT (1H+,9X,' FOR SUBJECT NO.',I5)
103   FORMAT (1H1,'RCMAT -- PROBLEM NUMBER',I3)
      END
```

Appendix B

Sample Output Data for Individual Subjects

STIMULUS WORD	CODE NO.
FACTOR	1
CORRELATION	2
DISTRIBUTION	3
SKEWNESS	4
NORMALITY	5

RC MATRIX FOR SUBJECT NO. 1

	1	2	3	4	5
1	1.000	0.267	0.0	0.0	0.0
2	0.267	1.000	0.0	0.0	0.0
3	0.0	0.0	1.000	0.333	0.276
4	0.0	0.0	0.333	1.000	0.222
5	0.0	0.0	0.276	0.222	1.000

RC MATRIX FOR SUBJECT NO. 2

	1	2	3	4	5
1	1.000	0.504	0.074	0.0	0.0
2	0.504	1.000	0.151	0.0	0.0
3	0.074	0.151	1.000	0.648	0.222
4	0.0	0.0	0.648	1.000	0.231
5	0.0	0.0	0.222	0.231	1.000

RC MATRIX FOR SUBJECT NO. 3

	1	2	3	4	5
1	1.000	0.222	0.0	0.0	0.0
2	0.222	1.000	0.0	0.0	0.0
3	0.0	0.0	1.000	0.344	0.0
4	0.0	0.0	0.344	1.000	0.370
5	0.0	0.0	0.0	0.370	1.000

RC MATRIX FOR SUBJECT NO. 4

	1	2	3	4	5
1	1.000	0.400	0.0	0.0	0.0
2	0.400	1.000	0.0	0.0	0.0
3	0.0	0.0	1.000	0.0	0.370
4	0.0	0.0	0.0	1.000	0.278
5	0.0	0.0	0.370	0.278	1.000

RC MATRIX FOR SUBJECT NO. 5

	1	2	3	4	5
1	1.000	0.0	0.0	0.0	0.0
2	0.0	1.000	0.0	0.0	0.0
3	0.0	0.0	1.000	0.185	0.0
4	0.0	0.0	0.185	1.000	0.0
5	0.0	0.0	0.0	0.0	1.000

RC MATRIX

	1	2	3	4	5
1	1.000	0.278	0.015	0.0	0.0
2	0.278	1.000	0.030	0.0	0.0
3	0.015	0.030	1.000	0.302	0.174
4	0.0	0.0	0.302	1.000	0.220
5	0.0	0.0	0.174	0.220	1.000

Appendix C
Sample Output Data for Pooled RC's

SPONSES TO STIMULUS WORD : FACTOR

	FREQ	ORDER	RANK
FACTOR	5.	5.	1.00
CORRELATION	2.	5.	2.50
COMMUNALITY	2.	5.	2.50
ROTATION	2.	6.	4.00
LOADING	2.	7.	5.00
MATRIX	2.	8.	6.00
ANALYSIS	2.	11.	7.00
AXES	1.	2.	8.50
EIGENVALUE	1.	2.	8.50
CLUSTER	1.	3.	10.00
RESIDUAL	1.	4.	11.00
COMPLEXITY	1.	5.	12.00
COSINE	1.	6.	13.50
VARIABLE	1.	6.	13.50

ESPONSES TO STIMULUS WORD : CORRELATION

	FREQ	ORDER	RANK
CORRELATION	5.	5.	1.00
MATRIX	3.	8.	2.00
MULTIPLE	2.	5.	3.00
FACTOR	2.	6.	4.50
SIGNIFICANCE	2.	6.	4.50
ANALYSIS	2.	9.	6.00
VARIABLE	2.	11.	7.00
BIAS	1.	2.	8.50
COEFFICIENT	1.	2.	8.50
BETA	1.	4.	10.00
PREDICTOR	1.	5.	11.00
LOADING	1.	6.	12.00

ESPONSES TO STIMULUS WORD : DISTRIBUTION

	FREQ	ORDER	RANK
DISTRIBUTION	5.	5.	1.00
SKEWNESS	3.	11.	2.00
MEAN	2.	5.	3.00
STATISTIC	2.	6.	4.00
KURTOSIS	2.	11.	5.00
SAMPLE	1.	2.	6.50
ANALYSIS	1.	2.	6.50
SIGNIFICANCE	1.	3.	9.50
F	1.	3.	9.50
STANDARD DEVIATION	1.	3.	9.50
CENTRAL TENDENCY	1.	3.	9.50
CHISQUARE	1.	4.	12.50
MOMENTS	1.	4.	12.50
CORRELATION	1.	5.	14.00

RESPONSES TO STIMULUS WORD : SKEWNESS

	FREQ	ORDER	RANK
SKEWNESS	5.	5.	1.00
SYMMETRY	2.	4.	2.00
DISTRIBUTION	2.	5.	4.00
KURTOSIS	2.	5.	4.00
NORMALITY	2.	5.	4.00
MEAN	2.	9.	6.00
OJIVE	1.	3.	7.00
MOMENTS	1.	4.	8.00
MODE	1.	5.	9.00
MEDIAN	1.	6.	10.00

RESPONSES TO STIMULUS WORD : NORMALITY

	FREQ	ORDER	RANK
NORMALITY	5.	5.	1.00
DISTRIBUTION	2.	5.	2.00
TEST	2.	7.	3.00
ASSUMPTION	1.	2.	4.50
MEAN	1.	2.	4.50
SKEWNESS	1.	3.	7.00
Z-SCORE	1.	3.	7.00
IDEAL	1.	3.	7.00
SYMMETRY	1.	4.	9.50
HYPOTHESIS	1.	4.	9.50

STIMULUS WORD	CODE NO.
FACTOR	1
CORRELATION	2
DISTRIBUTION	3
SKEWNESS	4
NORMALITY	5

RC MATRIX

	1	2	3	4	5
1	1.000	0.545	0.079	0.0	0.0
2	0.545	1.000	0.146	0.0	0.0
3	0.079	0.146	1.000	0.564	0.406
4	0.0	0.0	0.564	1.000	0.570
5	0.0	0.0	0.406	0.570	1.000

REFERENCES

Cramer, P. *Word Association.* New York: Academic Press, 1968.

Deese, J. On the Structure of Associative Meaning. *Psychological Review.* 1962, 69, 161-175.

Essex, D., and Liu, C. *A Methodology to Assess the Content and Structure of Affective and Descriptive Meanings Associated With the Work Environment.* Columbus, Ohio: The Center for Vocational Education, 1974.

Garskof, B.E., and Houston, J.P. Measurement of Verbal Relatedness: An Idiographic Approach. *Psychological Review.* 1963, 70, 277-288.

Johnson, P.E., and Collier, R.O. A Note on Methods of Indexing Associative Relatedness. *Behavior Research Methods & Instruction.* 1969, 1, 140-142.

Marshall, G.R., and Cofer, C.N. Associative Indices as Measures of Word Relatedness: A Summary and Comparison of Ten Methods. *Journal of Verbal Learning and Verbal Behavior.* 1963, 1, 408-421.

Moss, J.; Pucel, D.J.; Smith, B.B.; and Pratzner, F.C. An Empirical Procedure for Identifying the Structure of the Technical Concepts Possessed by Selected Workers. In B.B. Smith and J. Moss (Eds.), *Process and Techniques of Vocational Curriculum Development.* Minneapolis, Minnesota Research Coordinating Unit for Vocational Education, 1970.

Pratzner, F.C. Testing an Empirical Procedure for Identifying Technical Associative Conceptual Structure: Discriminating Between Workmen Within and Between Two Occupations. Unpublished Doctoral Dissertation, University of Minnesota, 1969.

Smith, B.B. Testing an Empirical Procedure for Identifying Technical Associative Conceptual Structure: Discriminating Between Flexible and Inflexible Radio and Television Repairmen. Unpublished Doctoral Dissertation, University of Minnesota, 1968.

Szalay, L.B., and Brent, J.E. The Analysis of Cultural Meaning Through Free Verbal Association. *Journal of Social Psychology.* 1967, 72 161-187.

Szalay, L.B.; Brent, J.E.; and Lysne, D.A. The Use of Word Associations for Value Analysis. *Proceedings of the 76th Annual Convention of the American Psychological Association.* 1968, pp. 643-644.