A RAND NOTE

PANEL Program User's Manual

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PREFACE

This Note is the user's manual for the PANEL program for latent class modeling of rater agreement. PANEL should be of interest to researchers concerned with assessing agreement on dichotomous ratings or diagnostic classifications, where ratings are provided by varying rater panels.

The revision of the PANEL program was made possible by support from the Behavioral Sciences Department of The RAND Corporation. The program and this manual benefited from helpful comments by RAND colleague Daniel Relles.

CONTENTS

TABLES

I. INTRODUCTION

This Note is the user's manual for the PANEL program. PANEL permits latent class modeling [1-3] of rater agreement given the following conditions:

- Ratings are dichotomous.
- The varying rating panel assumption (discussed in Refs. 4-6) is met; for example, the raters for each case are selected at random, or the multiple ratings come from replications of the same rating procedure.[1]
- Each case is rated the same number of times.

The statistical procedures used are described in the companion RAND Note, N-3029-RC, *Latent Structure Agreement Analysis* [5].

This program replaces the original version of PANEL [7]. That version used the Newton-Raphson algorithm for maximum likelihood estimation, and was limited to models with two latent classes. This version uses an EM maximum likelihood estimation algorithm, and can estimate models with multiple latent classes. It also allows for the application of constraints on model parameters.

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[1]Software for the analysis of fixed rating panel agreement data is described in App. B.

II. INSTRUCTIONS FOR INTERACTIVE USE

PROGRAM DESCRIPTION

PANEL can be run in interactive or batch mode. In interactive mode commands are supplied in response to program prompts. In batch mode instructions are provided with an input file. This section describes the use of the program in interactive mode. The following section contains instructions for running the program in batch mode.

PANEL is written in MicroSoft QuickBASIC, Version 4.0. Both the compiled program (PANEL.EXE) and source code (PANEL.BAS) are contained on the distribution diskette. Only the former is necessary to run the program. To execute the program, type the command PANEL and press the Enter key.

The program issues a series of prompts before analyzing the problem and providing results. These prompts are described below.

INPUT AND OUTPUT FILES

First, the program prompts for the name of a file with the data to be analyzed. Enter any valid DOS file name, including extension and path, if applicable. This file should contain the numbers of cases in the sample receiving 0, 1, ..., k (where k is the number of ratings per case) positive ratings. These may be typed on the same line, with spaces between them, or on separate lines (see App. A).

The program then asks for the name of the output file on which results will be printed. Enter a valid DOS file name. The program will ask if you want to write over or append to any existing results in this file.

DESIGN SPECIFICATION

Number of Ratings per Case

The next prompt asks for the number of ratings per case. Allowable values are from two to 12. Enter the appropriate number, and press the Enter key.

Number of Latent Classes

The following prompt requests the number of latent classes in the model to be considered. Allowable values are from one to five. Type the desired number, and press the Enter key.

For either of the two above prompts, entering a nonzero value outside the allowable range will cause an error message; you can stop the program by entering a zero.

Parameter Constraints

The next prompt asks if parameters are to be constrained. The use of parameter constraints in latent class analysis of rater agreement is described in Refs. 5 and 8-10. At present, PANEL permits only fixed value constraints, by which parameters are set to specified values. To estimate a constrained model, respond to this prompt by typing "y" and pressing the Enter key.

If this option is selected, the next prompt will ask for the name of the file with constraint information. Any valid DOS file name may be specified.

This file must contain a number corresponding to each model parameter. If a parameter is to be unconstrained, indicate this with a -1. If a parameter is to be constrained to some value (from 0 to 1, inclusive), enter this number. These numbers may be in any format, provided that spaces separate values on the same line. The order, however, is important. Values should be entered as follows: first, enter constraint information for latent class prevalences (see Sec. IV for definition of terms), beginning with the lowest numbered latent class and ending with the highest numbered latent class; as discussed in Ref. 5, latent classes are numbered in order of increasing probability of eliciting a positive rating. Next, enter constraint information for the conditional positive rating probabilities; again, order values from the lowest- to the highest-numbered latent class. Thus, for a model with C latent classes, there should be 2C numbers entered in this file.

Estimated Rating Accuracy Indices

The next prompt asks if estimates of rating accuracy are to be calculated. The indices calculated are sensitivity, specificity, positive predictive validity, and negative predictive validity [5, 11].

These indices are defined only with regard to a dichotomous trait (e.g., disease absent/disease present). For models with two latent classes, PANEL assumes that the lower-numbered latent class corresponds to negative trait status and the higher-numbered latent class to positive trait status. If there are more than two latent classes, you must specify whether each is viewed as a type of negative or positive case. In interactive mode, PANEL will prompt for the name of a file with this information. This file must contain one number corresponding to each latent class. Indicate whether each latent class is viewed as a type of negative or positive case with a 0 or 1, respectively. Order these from the lowest- to the highest-numbered latent class. Values may be typed on the same line, with separating spaces, or on different lines.

CALCULATIONS

After the necessary design information has been supplied, the program iteratively estimates model parameters using the EM algorithm. Iterations continue until convergence is achieved. Convergence is defined as a difference in the log-likelihood obtained on successive iterations of .00000001 (10E-8) or less.[1]

The screen is updated as the program performs iterations. The iteration being performed is displayed in the upper right, below the number of cases. The log-likelihood and change in log-likelihood are

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[1]In batch mode, the user may alternatively request that a specified number of iterations be performed.

also shown. Iterations may be interrupted at any point by pressing the Escape key.

RESULTS

Intermediate results are displayed as iterations are performed. Once convergence is achieved, final parameter estimates and summary information are displayed. The results provided are as follows:

Observed and Expected Frequencies and Proportions

The main display screen is divided into several fields. The first, in the upper left, shows the observed frequency (n) and proportion (p) of cases with each number of positive ratings. Also shown are the corresponding expected frequencies ($E(n)$) and proportions ($E(p)$).

Goodness-of-Fit Statistics

Indices of model fit appear to the right. Both Pearson (PN) and likelihood ratio (LR) chi-square statistics [1, 5] are shown, as well as the associated degrees of freedom (see Sec. IV). After iterations are completed, the program also calculates and displays the normed fit index [12], which is analogous to the proportion of variance accounted for by the latent class model [5, 13].

Parameter Estimates

The lower portion of the screen contains model parameter estimates. For each latent class, shown are the estimated prevalence of that class, and the estimated conditional probability of a negative and positive rating, given a case belonging to that class.

Classification Probabilities

The program informs the user once convergence is achieved. Pressing any key will then cause a new display to appear. This contains classification probabilities, or the estimated probability that a case with each possible number of positive ratings belongs to each latent class.

Accuracy Indices

If the accuracy indices option is selected, pressing any key will then cause these to be displayed.

OPTIONAL NEWTON-RAPHSON ESTIMATION

For models with four or five latent classes, it may require as many as several thousand iterations for the program to converge using the EM algorithm. A feature has therefore been added whereby the user may interrupt the EM algorithm and use a Newton-Raphson estimation procedure, which converges more rapidly. To use this option, wait until the EM algorithm has generated parameter estimates that appear fairly stable--usually 50 to 100 iterations will be sufficient. Then call the Newton-Raphson procedure by pressing the F2 special function key.

The screen display will then change, and the routine will perform the first Newton-Raphson iteration. When this is completed, the program will beep, and new estimates will be displayed. At the top of the screen, on the right, is the Iterate/Return indicator. This is initially set to the Iterate mode; each time that you press the Enter key, the routine will perform another iteration. The differences between current and previous estimates are shown in parentheses. Approximate convergence is indicated when these are zero. It should usually take no more than 20 iterations for this to occur. When approximate convergence is achieved, use the left or right arrow key to toggle the Iterate/Return indicator back to the Return position, press the Enter key, and the program will return to the EM algorithm mode. At this point the original parameter estimate display will return, showing the new estimates and expected frequencies and proportions of various numbers of positive ratings. The program may then continue for several iterations in EM mode until complete convergence is achieved.[2]

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[2]The log-likelihood is displayed for each iteration of the Newton-Raphson estimation procedure. Because rounding error affects the Newton-Raphson and EM algorithms differently, small discrepancies may occur between maximum likelihood estimates obtained by the two methods. These may be enough to cause the log-likelihood to appear to momentarily increase as the program returns from the Newton-Raphson mode to EM mode.

If an arithmetic error occurs during the Newton-Raphson procedure or a parameter estimate is obtained that is outside the range of 0 to 1, an error message will appear.[3] The program will then return to the EM algorithm, using the last set of estimates obtained in that mode, and proceed as if the Newton-Raphson procedure had not been used. The Newton-Raphson procedure may be called again after the EM algorithm has run through a sufficient number of iterations to provide good starting values.

This option is not implemented for one-class models.

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[3]This will generally occur because an insufficient number of EM iterations took place before the Newton-Raphson procedure was called, and the initial estimates used to start the Newton-Raphson procedure were too far from maximum likelihood estimates.

III. RUNNING PANEL IN BATCH MODE

To run PANEL in batch mode, initially enter the command PANEL/B rather than PANEL. In batch mode, design parameters and data are supplied by an input file named INPUT. Results are automatically printed on a file named OUTPUT (any previous results stored on OUTPUT will be erased).

The input should be typed according to the following format:

Basic Design Information

LINE 1 -- Problem title (up to 80 characters of text)

LINE 2 -- Model design and options, as follows:

Columns	Format	Information
1 - 2	I2	Number of ratings per case (from 2 to 12)
3 - 4	I2	Number of latent classes (from 1 to 5)
5 - 8	I4	Number of iterations
9 - 10	I2	Parameter constraints (1 = yes, 0 = no)
11 - 12	I2	Accuracy indices option (1 = yes, 0 = no)
13 - 14	I2	Suppress standard errors (1 = yes, 0 = no)

Observed Data

On the next line(s) indicate the observed frequency of cases receiving exactly 0, 1, ..., the maximum possible number of positive ratings; these may be typed on separate lines or on the same line with separating spaces.

Parameter Constraints

If the parameter constraint option is selected, provide constraint information on the following line(s). Follow the same format and order conventions as for specifying constraints in interactive mode.

Accuracy Indices Option

If the option to calculate estimated indices of rating accuracy is selected, and if the number of latent classes is greater than two, indicate on the following line(s) whether each latent class is to be viewed as a type of positive or negative case. Follow the conventions described for interactive use of the program.

Note that the program will perform the number of iterations specified, regardless of the difference in the log-likelihood between successive iterations. If Cols. 5-8 are blank, iterations will proceed until a difference of 10E-8 is achieved, as in interactive mode. Example batch input files are shown in App. A.

IV. ESTIMATION PROCEDURE

PARAMETERS

Observed frequencies of cases with 0, 1, ..., k positive ratings, where k is the number of ratings per case, are read from the input file. Dividing these by the total number of cases, N, observed proportions of cases with each possible number of positive ratings are obtained, denoted

$$p_0, \quad p_1, \quad \ldots, \quad p_k.$$

In accordance with the varying panel latent class model discussed in Refs. 4-6, these proportions are assumed to be determined by two sets of parameters: the probabilities of sampling a case belonging to each latent class (*latent class prevalences*), and the conditional probabilities of positive and negative ratings, given a case belonging to each latent class (*conditional rating probabilities*). The latent class prevalences are denoted by

$$\pi_1, \quad \pi_2, \quad \ldots, \quad \pi_c,$$

where π_s (s = 1, 2, ..., c) is the probability of a randomly sampled case belonging to latent class s. The conditional rating probabilities are denoted by

$$\pi_{0|1}, \quad \pi_{0|2}, \quad \ldots, \quad \pi_{0|c},$$

and

$$\pi_{1|1}, \quad \pi_{1|2}, \quad \ldots, \quad \pi_{1|c},$$

where $\pi_{0|s}$ and $\pi_{1|s}$ indicate the probability of a negative or a positive rating, respectively, given a member of latent class s. Note that since, for each latent class s, $\pi_{0|s}$ and $\pi_{1|s}$ sum to one, only one must be estimated. We shall therefore be concerned only with the $\pi_{1|s}$ parameters.

PROBABILITY MODEL

The joint probability of exactly j positive ratings (j = 0, 1, ..., k) and a case belonging to latent class s (s = 1, 2, ..., c) is denoted by $\pi_{j,s}$. Considering all possible numbers of positive ratings and all latent classes leads to the array of joint probabilities

$$\begin{array}{llll} \pi_{0,1}, & \pi_{0,2}, & \ldots, & \pi_{0,c} \\ \pi_{1,1}, & \pi_{1,2}, & \ldots, & \pi_{1,c} \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \cdot & \cdot & & \cdot \\ \pi_{k,1}, & \pi_{k,2}, & \ldots, & \pi_{k,c}, \end{array}$$

where each element $\pi_{j,s}$ is calculated from latent class prevalences and conditional rating probabilities by the formula,

$$\pi_{j,s} = \pi_s \binom{k}{j} \pi_{1|s}{}^{j} (1 - \pi_{1|s})^{k-j}. \tag{1}$$

The unconditional probabilities for various numbers of positive ratings are obtained as the row marginals of the above array. Thus, the unconditional probability of a case obtaining exactly j positive ratings is

$$\pi_{j.} = \pi_{j,1} + \pi_{j,2} + \ldots + \pi_{j,c}, \tag{2}$$

where the . subscript indicates a marginal sum. This leads to the set of unconditional probabilities for various numbers of positive ratings,

$$\pi_{0.}, \quad \pi_{1.}, \quad \ldots, \quad \pi_{k.}.$$

As described in Refs. 4-6, maximum likelihood estimates $\hat{\pi}_s$ and $\hat{\pi}_{1|s}$ (s = 1, 2, ..., c) for latent class prevalences and conditional positive rating probabilities are obtained using either the EM or Newton-Raphson (or comparable) method.

MODEL FIT AND COMPARISON

The fit of a latent class agreement model is assessed with the Pearson or likelihood ratio chi-square statistic [1, 5]. Let the observed frequencies of cases with j (j = 0, 1, ..., k) positive ratings be denoted by

$$f_0, \quad f_1, \quad \ldots, \quad f_k,$$

and the corresponding frequencies expected under a particular latent class model by

$$e_0, \quad e_1, \quad \ldots, \quad e_k,$$

where $e_j = N\hat{\pi}_{j.}$, and $\hat{\pi}_{j.}$ is the estimated unconditional probability of exactly j positive ratings obtained from use of latent class prevalence and conditional positive rating probability estimates in Eqs. (1) and (2).

The log-likelihood function is

$$\log L = \sum_{j=0}^{k} f_j \log(\pi_{j.}). \tag{3}$$

The Pearson chi-square statistic is calculated by the formula

$$\chi^2 = \sum_{j=0}^{k} (f_j - e_j)^2/e_j, \tag{4}$$

and the likelihood ratio chi-square statistic by the formula

$$L^2 = 2 \sum_{j=0}^{k} f_j \log(f_j/e_j). \tag{5}$$

Each chi-square statistic has degrees of freedom equal to k minus the number of estimated parameters. For unconstrained models, $c - 1$ prevalences and c conditional positive rating probabilities, or a total of $2c - 1$ parameters, are estimated. Each constrained parameter reduces the number of estimated parameters and increases the degrees of freedom for the chi-square test by 1. If a parameter estimate converges to a boundary value of 1 or 0, the parameter is fixed at that value, increasing the degrees of freedom for the chi-square test by 1.

V. EXAMPLE

A computational example of latent class agreement analysis with varying rating panels is presented in Ref. 5 and we therefore do not provide one here. The sample data and results below, however, will allow the user to verify that the program is running correctly.

Table 5.1 shows data on ratings by varying panels of eight physicians concerning whether chest x-rays appeared positive or negative for tuberculosis [5, 14]. Observed frequencies of cases with 0, 1, ..., 8 positive ratings were obtained as indicated. Also shown are expected frequencies corresponding to two latent class models, denoted M_1 and M_2. Model M_1 corresponds to an unconstrained model with three latent classes (this is identical to Model M_3 in Ref. 5). Model M_2 adds an additional latent class of perfectly recognizable positive cases--that is, a latent class such that the probability of a positive rating is 1.

Model fit, parameter estimates and standard errors, and estimated rating accuracy indices for these models are shown in Tables 5.2-5.4. Input files for generating these results are listed in App. A.

Table 5.1

OBSERVED AND EXPECTED PANEL OUTCOME FREQUENCIES

Number of Positive Ratings j	Observed Frequencies f_j	Expected Frequencies e_j Model	
		M_1	M_2
0	13560	13557.27	13558.97
1	877	883.24	879.49
2	168	146.65	158.06
3	66	92.25	81.98
4	42	42.24	34.53
5	28	16.39	23.46
6	23	21.68	32.53
7	39	50.51	33.97
8	64	56.76	64.00

Table 5.2

COMPARISON OF ALTERNATIVE MODELS

Model	Number of Latent Classes	log L	χ^2	L^2	df	Normed Fit Index
M_1	3	-6003.166	22.473	21.897	3	0.997
M_2	4	-5997.278	9.779	10.122	2	0.999

NOTE: L^2 for a one-class model is 7160.808, with 7 df.

Table 5.3

PARAMETER ESTIMATES AND APPROXIMATE STANDARD ERRORS

	Model M_1		Model M_2	
Parameter	Estimate	Std. Error	Estimate	Std. Error
π_1	0.9636	0.0027	0.9589	0.0041
π_2	0.0275	0.0024	0.0308	0.0037
π_3	0.0088	0.0008	0.0071	0.0009
π_4	--	--	0.0032	0.0007
$\pi_{1\|1}$	0.0072	0.0003	0.0068	0.0004
$\pi_{1\|2}$	0.2660	0.0177	0.2232	0.0231
$\pi_{1\|3}$	0.9003	0.0134	0.7898	0.0349
$\pi_{1\|4}$	--	--	1.0000	--

NOTE: Standard errors are obtained as the square roots of -1 times the diagonal elements of the inverse of the information matrix [3].

Table 5.4

ESTIMATED RATING ACCURACY INDICES

Accuracy Index	Model M_1	Model M_2
Rating Sensitivity	0.9003	0.8557
Rating Specificity	0.9856	0.9865
Positive Predictive Validity	0.3585	0.3971
Negative Predictive Validity	0.9991	0.9985

VI. AVAILABILITY

Copies of PANEL on a floppy diskette may be obtained from the Publications Department, The RAND Corporation. Alternatively, they may be obtained directly from the author at the address shown below. There is a nominal charge of $9.00 to cover the cost of material and mailing.

Please contact the author if the program does not work properly or if there are questions concerning its use.

The author's address is:

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Appendix A

EXAMPLE INPUT FILES

The following batch input files correspond to Models M_1 and M_2, respectively, described in Sec. V.

A copy the first file is included on the distribution diskette. Note that this must be renamed INPUT and the program run in batch mode using the PANEL/B command.

Example 1

```
Yerushalmy X-Ray Rating Data:  Three-Class Unconstrained Model
 8 3 100   1
13560 877 168 66 42 28 23 39 64
   0   0   1
```

Example 2

```
Yerushalmy X-Ray Rating Data:  Four-Class Constrained Model
 8 4 250 1 1
13560 877 168 66 42 28 23 39 64
  -1  -1  -1  -1
  -1  -1  -1   1.
   0   0   1   1
```

Appendix B

RELATED SOFTWARE

To analyze agreement data that correspond to a fixed rating panel design [5, 6, 8-10] any of several latent class analysis programs may be used. Below are listed several such programs that are currently available in microcomputer form and the authors' addresses.

MLLSA-PC
Clifford Clogg and Scott Eliason
Department of Statistics
The Pennsylvania State University
University Park, Pennsylvania 16802

LAT
Shelby J. Haberman
Department of Statistics
Northwestern University
Evanston, Illinois 60208

PANMARK
Frank van de Pol, Rolf Langeheine,
and Wil de Jong
Netherlands Central Bureau of Statistics
Department of Statistical Methods
P.O. Box 959
2270 AZ VOORBURG
The Netherlands

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