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Manual for GENOVA: A GENeralized Analysis Of VAriance System

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ACT

Manual for GENOVA:

A GENeralized Analysis Of VAriance System

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Table of Contents

List of Tables.....v
List of Figures.....v
Foreword.....vii

CHAPTER 1
INTRODUCTION.....1-1
Audiences.....1-2
GENOVA Notation.....1-2
GENOVA Restrictions.....1-3
GENOVA Input Conventions.....1-3
Specifying Input Order.....1-4
Calculating Record Size.....1-4
Organization of Manual.....1-5

CHAPTER 2
SIMPLE EXECUTIONS OF GENOVA.....2-1
Control Cards and Input Data Matrix for Simple Runs.....2-4
STUDY Card, EFFECT Cards and PROCESS Card.....2-5
FORMAT Card, COMMENT Card and OPTIONS Card.....2-6
FINISH Card.....2-6
Simple Run No. 1 Control Cards and Data.....2-7
Output for Simple Run No. 1.....2-9
Title Page and Control Card Listing.....2-9
Expanded Main and Interaction Effect Table.....2-9
Input Record Listing with Record Means.....2-10
Cell Mean Scores.....2-10
Sums of Squares, Mean Squares and F-Statistics.....2-10
Estimated Variance Components and Standard Errors....2-11
Standard Errors.....2-11
Expected Mean Square Equations.....2-12
Variance-Covariance Matrix.....2-12
Correlation Matrix for Estimated Variance Components.2-12
Simple Run No. 2 Control Cards, Data and Results.....2-12

CHAPTER 3
DECISION (D) STUDIES.....3-1
DSTUDY Cards.....3-1
DEFFECT Cards.....3-3
Sample Size Interactions.....3-3
ENDDSTUDY Card.....3-4
DCUT Card.....3-4
Specifying Cutting Scores.....3-4
D Study OPTIONS Card Parameters.....3-5
D Study Output.....3-5

CHAPTER 4
OTHER FEATURES OF GENOVA AND TECHNICAL CONSIDERATIONS.....4-1
Other Features.....4-1

Using Mean Squares as Input.....4-1
Using Variance Components as Input.....4-5
Additional OPTIONS Card Parameters.....4-8
Altering the Output Logical Unit.....4-8
Specifying Descriptions for Facets in a STUDY Run.....4-8
Specifying Subheadings for Reports.....4-9
Rewinding Logical Units.....4-9
Using Alternate Logical Units for Control Card Input.4-12
Computer-Related Technical Considerations.....4-16
GENOVA Modules.....4-16
Implementation Considerations.....4-16
Data Storage Restrictions.....4-17
File Assignments in GENOVA.....4-17
System Control Cards for GENOVA.....4-17
Execution Times.....4-20
Core Requirements.....4-20

APPENDIX A
FULL DESCRIPTION OF CONTROL CARDS AND FIELDS.....A-1
Continuation Cards.....A-2
COMMENT Card.....A-3
DCUT Card.....A-4
DEFFECT Card.....A-6
DSTUDY Card.....A-9
EFFECT Card.....A-10
ENDCOMP Card.....A-12
ENDDSTUDY Card.....A-13
ENDMEAN Card.....A-14
FINISH Card.....A-15
FORMAT Card.....A-16
GCOMPONENTS Card.....A-17
GMEANSQUARES Card.....A-18
GSTUDY Card.....A-19
MEANSQUARE Card.....A-20
NAME Card.....A-22
OPTIONS Card.....A-23
OUTPUT Card.....A-26
PROCESS Card.....A-27
READ Card.....A-28
REWIND Card.....A-29
REVERT Card.....A-30
STUDY Card.....A-31
SUBHEADING Card.....A-32
VCOMPONENT Card.....A-33

APPENDIX B
OUTPUT FOR SIMPLE RUNS.....B-1

APPENDIX C
OUTPUT FOR D STUDY RUNS.....C-1

APPENDIX D
REFERENCES.....D-1

List of Tables

2.1 GENOVA Control Cards for Simple Runs.....2-2,2-3

4.1 Default GENOVA Logical Unit Assignments.....4-17

A.1 GENOVA Control Card Ordering.....A-35

List of Figures

2.1 Control Cards for Simple Run No. 1.....2-7

2.2 Control Cards for Simple Run No. 2.....2-14

3.1 Sample Control Card Input for D Study Analyses.....3-2

4.1 Sample Control Cards for Mean Squares Input.....4-2

4.2 Control Card Listing and Study Results for Mean Squares Input.....4-3

4.3 Variance Components, Standard Errors and Variance - Covariance Matrix for Mean Squares Input.....4-4

4.4 Sample Control Cards for Variance Components Input....4-6

4.5 Partial Output for Variance Components Input.....4-7

4.6 Sample GENOVA Output with 'NAME' and 'SUBHEADING' Control Cards.....4-10

4.7 Sample GENOVA Runs Using the Rewind Card.....4-11

4.8 Sample Control Cards Using the READ and REWIND Cards.....4-13

4.9 Sample Alternate Input File Using the REVERT Card....4-14

4.10 Sample Control Card Listing for Figures 4.8 and 4.9..4-15

4.11 Illustrative CDC CCL Set-ups.....4-18

4.12 Illustrative IBM JCL Set-ups.....4-19

FOREWORD

In 1972 Cronback, Gleser, Nanda, and Rajaratnam (1972) published a comprehensive monograph on the topic of generalizability theory which deals with the dependability of behavioral measurements. No single statement can adequately characterize generalizability theory, but any such characterization would emphasize the central role of variance components associated with facets (factors, dimensions, or classifications of conditions) in a universe. In the terminology of generalizability theory such variance components are estimated from a G study (or possibly several G studies) that typically involves an analysis-of-variance-type design. Consequently, if one were to describe generalizability theory to persons with traditional statistical training but little knowledge of educational and psychological measurement, one might say that generalizability theory involves, in part, the application of analysis of variance techniques to measurement procedures encountered in the behavioral sciences -- especially education and psychology.

Even though analysis of variance and experimental design partly characterize both generalizability theory and classical statistics, there are differences in emphasis, terminology, and the types of designs typically encountered. For example, the designs used in generalizability theory usually have a single observation in each cell, rather than replications within cells; and emphasis is placed upon the estimation of variance components, rather than tests of statistical significance. Also, for mixed models, the manner in which score effects are defined in generalizability theory means that the "usual" constraints (sum of effects equalling zero) are always imposed -- or, to put it another way, these constraints play the role of restrictions on the general linear model in generalizability theory (see Brennan, Jarjoura, & Deaton, 1980). As noted by Searle (1971, pp. 389-404), these constraints or restrictions affect the definition and, hence, the estimation of variance components.

Given the differences noted above between applications of generalizability theory and classical statistical treatments of analysis of variance, many currently available computer programs for analysis of variance have limitations when used for applications of generalizability theory. GENOVA circumvents most of these limitations without introducing complexities in the use of the program. For example, many analysis of variance programs require massive amounts of core when used with designs characterized by single observations in cells, especially when such programs operate directly on a design matrix. By contrast, the core requirements for GENOVA are unconstrainted by the nature of the design. Also, GENOVA emphasizes estimated variance components and other related output (including standard errors), rather than F-statistics.

GENOVA has been developed principally to complement a monograph entitled Elements of Generalizability Theory (Brennan, 1983), which contains a mini-manual for GENOVA. Indeed, many of the algorithms and procedures used by GENOVA are discussed, directly or indirectly, in Elements of Generalizability Theory.

Although the principal motivation for the development of GENOVA centered on applications of generalizability theory, GENOVA has broader applicability. As the acronym suggests, GENOVA could be described as a general purpose (or generalized) analysis of variance system for complete, balanced designs; and, as such, GENOVA should be useful to researchers and practitioners in many fields who have interest in applied aspects of analysis of variance.

From the perspective of generalizability theory, GENOVA handles G studies and the estimation of variance components as well as the estimation of quantities associated with D studies (decision studies). GENOVA will handle most aspects of the vast majority of current applications of univariate generalizability theory.

The development of an earlier version of GENOVA was made possible primarily by a contract (Contract No. N00123-78-C-1206) between The American College Testing Program (ACT) and the Navy Personnel Research and Development Center (NPRDC), with Robert L. Brennan as principal investigator. The authors wish to thank NPRDC and especially Dr. Pat-Anthony Federico, who served as contract monitor. Also, the authors are grateful to Dr. David Jarjoura of ACT, who offered several very constructive suggestions during the process of developing GENOVA. Finally, the authors thank Dr. Thomas Marx of Cambridge, Massachusetts, for his criticisms of a previous version of this manual.

CHAPTER 1

INTRODUCTION

GENOVA is a GENeralized analysis Of VAriance system that can handle a large class of complete, balanced ANOVA designs including:

fully crossed,
nested,
split-plot factorial,
randomized block,
most repeated measures designs, and
any design that the BMDØ8V or BMDP8V program can handle (see discussion of GENOVA notation).

In setting up a typical GENOVA run, the user specifies the main effects for the design and GENOVA determines all of the possible interaction effects. In other words, GENOVA is appropriate for "complete" designs -- i.e., designs in which all possible interaction effects are represented. Conversely, GENOVA is not intended for designs such as latin squares in which some (or all) interaction effects are assumed to be zero or are absent by the very nature of the design.

The major features of GENOVA include the following:

1) The ability to handle very large data sets: GENOVA's memory requirements are independent of the number of observations in the design.
2) Easy-to-use control cards.
3) Extensive standard and optional outputs including:
   a) EMS equations
   b) F statistics and some Quasi-F statistics
   c) Variance components and their standard errors
   d) Variance-covariance matrix of the estimated variance components
   e) Optional correlation matrix associated with the variance-covariance matrix in d, above
   f) Optional printing of the first and last 'n' input records with the record means (default 'n' = 1Ø)
   g) Optional printing of most cell means
4) Speed and efficiency of operation.
5) Ability to input mean squares from a previous study to generate most of the same reports as with raw data.
6) Ability to input variance components from a previous study to generate standard errors, EMS equations and the variance-covariance matrix.
7) Use of double precision throughout to insure the highest possible accuracy.
8) Ability to perform D studies (decision studies) with optional output for cutting scores.

Audiences

GENOVA is addressed to two audiences: (1) statisticians and data analysts interested in applications of analysis of variance and (2) psychometricians and measurement specialists interested in applications of generalizability theory.

There is some terminology in this manual which is probably more meaningful to the second audience, but the issues with respect to variance components and ANOVA are the same for both audiences. On the other hand, F and Quasi-F statistics reported by GENOVA are commonly used by statisticians but are generally not used by psychometricians interested in generalizability theory.

GENOVA Notation

The first steps in performing a study involve the usual initial procedures for an analysis of variance: defining the model and determining sums of squares, degrees of freedom, and mean squares for each of the effects in the study design.

The notational system used in GENOVA, as well as most of the computational algorithms, is taken from Brennan (1983). Using the symbol "x" to mean "crossed with" and ":" to mean "nested within," most common ANOVA designs can be represented by a suitable sequence of facets and symbols. Brennan (1983) represents facets in a G study by lower case letters, e.g. a, i, p, t, etc.

The two synthetic data sets used as examples in the first section of this manual are the designs p x (i:t) and s : (a x b x c), respectively. For the first design, the main effects are denoted as p, t, and i:t. For the second design, the main effects are simply a, b, c, and s:abc.

GENOVA also uses single letters of the alphabet to denote facets and ":" to denote nesting; however, the "x" symbol is not used in representing interaction effects. The interaction effects for the p x (i:t) design will be printed out by GENOVA as **PT** and **PI:T**, and the interaction effects for the second design will be printed out as **AB**, **BC** and **ABC**.

In this manual, lower case letters representing facets are sometimes referred to as indices or design variables. Furthermore, these letters are used to represent effects associated with a design. To avoid some convoluted verbal terminology, the terms "main effect" and "facet" will be used somewhat interchangeably, on occasion, although there is a distinction between these terms. For example, in the p x (i:t) design, the facets are, technically, p, t and i -- while the main effects are p, t and i:t. (Note also that, depending on the context, we may or mat not distinguish between the "facets" and

"objects of measurement," as these terms are used in generalizability theory.)

Therefore, in the p x (i:t) design i is not technically a main effect; rather, it is (what we later call) a primary index in a main effect. Moreover, any reference to the number of levels for a main effect, like i:t, usually refers to the number of levels for the facet i -- not both facets i and t. (To be technically correct, we would speak about the number of levels associated with the primary index, i, in the main effect i:t.)

GENOVA Restrictions

There are only four main restrictions for GENOVA processing:

1. The number of levels for any facet must be greater than or equal to 2.
2. The maximum number of facets for a single study is six. The minimum, of course, is two. (N.B. What statisticians sometimes refer to as the "observational unit" is considered as a facet throughout this manual.)
3. The design must be balanced or orthogonal.
4. The design must be "complete" in the sense that all possible interaction effects are included in the linear model.

As long as the ANOVA design can be specified in the GENOVA notation and the data can be organized to meet the GENOVA input conventions, the study can be performed by GENOVA.

GENOVA Input Conventions

Because GENOVA has been designed to be able to process an unlimited number of observations, certain input conventions are required to organize and specify data to take advantage of the GENOVA processing capabilities. Specifically, the GENOVA input conventions are:

1. The number of levels for each facet (sample sizes) must be specified.
2. All facets must be specified to GENOVA in a specific order: from slowest varying index to fastest.
3. The record variable (known as the 'starred' variable or facet) must be specified by a '*' on the 'EFFECT' control card.
4. If any facets are specified before the starred facet, then the starred facet must be nested within these preceding facets.

Specifying Input Order

Facets are specified to GENOVA via a set of EFFECT cards. The EFFECT control card for the slowest varying facet must be specified first; the EFFECT control card for the next slowest moving facet must be second; ..., the EFFECT control card for the fastest moving facet must be last. Suppose that the facets for a study were specified in the following order:

```
* P 5
T 4
I:T 3
```

This would imply that the first data value read would be for P=1, T=1, I=1; the second value for P=1, T=1, I=2; ...; the fourth value for P=1, T=2, I=1; ...; the thirteenth value for P=2, T=1, I=1, etc. It is important to understand the input order conventions to insure that the data are read properly by GENOVA.

Calculating Record Size

One easy way to insure that the data are organized appropriately and the format is specified correctly is to check the user-supplied format and data file organization against the number of records (NUMREC) and number of values per record (INREC) as calculated by GENOVA.

The rules GENOVA uses to calculate INREC and NUMREC are the following:

1. Calculate **INREC** = the product the sample size values for facets which are specified after the starred facet. This is the number of values to be read for each record. If the starred facet is the last facet specified, **INREC** will = 1,
2. Calculate **NUMREC** = Total number of observations (product of sample sizes for all facets) divided by **INREC.** This value, **NUMREC,** is the number of records to be read by the user-specified format, which is discussed later.

Consider the following four facets and sample sizes specified to GENOVA in order:

```
A 2
B 3
C 4
S 5
```

The calculation of INREC and NUMREC for each possible location of the starred facet is as follows:

Starred facet = **A**
INREC = 3 times 4 times 5 = 60
NUMREC = 120 (total # of data points) divided by 60 = 2.

Starred facet = **B**
INREC = 4 times 5 = 20.
NUMREC = 120 divided by 20 = 6.

Starred facet = **C**
INREC = 5.
NUMREC = 120 divided by 5 = 24.

Starred facet = **S**
INREC = 1.
NUMREC = 120 divided by 1 = 120.

It should again be noted that any time the starred facet is the last one specified to GENOVA, this automatically means that GENOVA will be expecting exactly **one** value per record.

Organization of Manual

This manual is organized into four principal parts. This first chapter is intended to provide a general introduction to GENOVA, its main features, its notation and its input conventions.

Chapter 2, in conjunction with Appendix B, provides a complete description of how to use GENOVA for G studies and interpret the results for "simple" runs of the program. These "simple" runs, however, are very powerful and are probably sufficient for most users of GENOVA. An effort has been made in Chapter 2 to simplify explanations as much as possible without needlessly sacrificing information.

Chapter 3, in conjunction with Appendix C, provides a complete description of how to use GENOVA for D studies and how to interpret the results for sample D study runs of the program. These sample D studies will give a relatively complete view of the options and features of this component of GENOVA's processing capabilities.

Chapter 3 is of primary interest to those individuals interested in generalizability theory applications whereas Chapter 2 is of general interest to all audiences as described earlier.

Chapter 4, in conjunction with Appendix A, discusses additional features of GENOVA and technical considerations that are probably of less direct interest to the typical users for whom GENOVA is intended.

CHAPTER 2

SIMPLE EXECUTIONS OF GENOVA

Appendix A provides a complete description of all control cards for GENOVA, as well as a full description of all variables, or parameters, included on the control cards. Many studies, however, probably will not often require some of the more advanced features of GENOVA outlined in Appendix A and explained in Chapter 4. In this chapter, therefore, we consider control cards and parameters associated with simple runs of GENOVA.

There is, of course, some subjectivity in any judgment about what should be included (and excluded) in a discussion of "simple" runs of GENOVA. The judgments reflected in the content of this chapter resulted from the authors' assumption that many applications will not require the following features of GENOVA:

1. use of variance components as input to GENOVA;
2. use of mean squares as input to GENOVA;
3. use of names for facet characters used in a study;
4. the capability to redirect output to an alternate logical unit number;
5. the capability to specify sub-headings for GENOVA reports;
6. the ability to read control cards (and possibly data) intermittently from alternate logical unit numbers;
7. and the ability to rewind logical units from within GENOVA.

Eliminating these features from Chapter 2 considerably simplifies the task of introducing users to GENOVA, without imposing any unnecessary restrictions upon the user.

Here, the principal intention is to illustrate how to set up control cards for simple runs of GENOVA, and how to interpret and use the results provided by GENOVA. For these purposes, the control card setups in Figures 2.1 and 2.2 in this chapter and the corresponding output in Appendix B should be both useful and informative.

TABLE 2.1

GENOVA Control Cards for Simple Runs

Card	Columns	Variable	Default	Format	Description
STUDY	1-5	'STUDY'	None	A	Control card identifier
	13-8Ø	KITTLE	Blank	A	Study title or heading
EFFECT	1-6	'EFFECT'	None	A	Control Card identifier
	Variable	'*'	None	A	Indicates which facet will be the 'starred' facet: the '*' must appear on exactly one of the EFFECT cards for a given study -- one EFFECT card per facet in the design
	Variable	'+'	Optional	A	Indicates facets which are to have cell means printed: the '+' and '*' are mutually exclusive -- they cannot appear on the same EFFECT card
	Variable	MFACET	None	A	Facet desciptor in GENOVA notation: letters and colons
	Variable	NUMLEV	None	I	Sample size or number of observations (levels) for this facet
	Variable	NPOPUL	Infinite	I	Population or universe size for this facet (Optional: Zero ==> Infinity)

Note: 'Variable' means within columns 13-8Ø.

TABLE 2.1

GENOVA Control Cards for Simple Runs
(Continued)

Card	Columns	Variable	Default	Format	Description
FORMAT	1-6	'FORMAT'	None	A	Control card identifier
	13-8Ø	KFORM	None	A	Object-time FORTRAN format for reading a data record. KFORM can be continued on up to two additonal cards
PROCESS	1-7	'PROCESS'	None	A	Control card identifier
	Variable	KDATA	5	I	Logical unit number for reading data matrix
FINISH	1-6	'FINISH'	None	A	Control card identifier -- terminates job
COMMENT	1-7	'COMMENT'	None	A	Control card identifier
	13-8Ø	None	Blank	A	User specified comment
OPTIONS	1-7	'OPTIONS'		A	Control card identifier
	13-8Ø	parameters	None	A	Various optional parameters controlling GENOVA output options

Note: 'Variable' means within columns 13-8Ø.

Control Cards and Input Data Matrix for Simple Runs

Each control card for the GENOVA program begins with a set of characters, called a control card identifier, in columns 1-12. At least the first four of these characters must be provided exactly as specified or an error message will be printed and the card in error will be ignored. Although all cards will be scanned, even if one or more identifier errors are detected, GENOVA will only execute a set of control cards if all necessary information has been processed without errors. (Note that GENOVA ignores all characters in columns 5-12 except for continuation cards which must be blank in columns 1-12. See Appendix A for a description of which control cards can have continuations.) The control card identifiers used in simple runs of GENOVA are listed below:

GSTUDY or **STUDY**

EFFECT

PROCESS

FINISH

COMMENT

OPTIONS

In general, a simple run of GENOVA consists of a GSTUDY or STUDY card (they are identical in function), a FORMAT card, several EFFECT cards and a PROCESS card. These cards, along with the input data, are sufficient to define an ANOVA study to GENOVA.

The final control card for every execution of GENOVA is a FINISH card. More than one study (initiated by a GSTUDY or STUDY card and completed by a PROCESS card and input data) can be specified before the FINISH card appears.

All parameters on GENOVA control cards appear in columns 13-80 and are free-format; they do not have to be placed in specific columns and multiple parameters on the same control card are separated by at least one comma and/or one space.

Table 2.1 lists each of the control cards, as well as the parameters associated with simple runs of GENOVA. (Again, a complete listing for these control cards and parameters, along with other control cards and parameters, is provided in Appendix A.)

Table 2.1 provides five types of information for each variable on each control card: (a) the columns (field) within which the user-specified value of the variable is to be provided; (b) the name of the variable; (c) a default value for the variable -- usually the value assigned to the variable if the field is not entered or left blank; (d) the FORTRAN format type used to read values of the variable; and (e) a brief description of the variable.

For each variable whose format is identified as I, the user-specified value of the variable should be an integer (i.e., a whole number without a decimal point).

When a variable requires a non-integer value or set of characters, the description of the variable specifies that it is read in A-format. A-format is used to read a set of alphanumeric characters (numbers, letters, or special characters).

STUDY Card, EFFECT Cards and PROCESS Card

The STUDY card specifies KTITLE, which is a user-specified heading that will be printed at the top of each page of output. Otherwise, KTITLE has no effect in GENOVA. This heading simply helps in documenting program output.

EFFECT cards are used to specify the facets involved in a particular study design. As discussed in Chapter 1, there must be one EFFECT card for each facet in the study (including the unit of observation or object of measurement "facet"), exactly one of the EFFECT cards must have a '*' on it to indicate the 'starred' facet, and the order of the EFFECT cards must reflect the organization of the input data matrix.

The general format of the data area (columns 13-80) of an EFFECT card is:

['*'or '+'] MFACET NUMLEV [NPOPUL]

The '*' must appear on exactly one EFFECT card and specifies that this facet is the starred facet. MFACET will be a character string of letters and colons describing a main effect following the GENOVA notation described in the previous chapter.

When a '+' appears on an EFFECT card, it signifies that cell means are to be printed out for all effects which contain only this facet and/or other facets which have been specified for cell mean output (a '+' on their respective EFFECT cards). Note that a '*' and a '+' cannot appear on the same EFFECT card.

NUMLEV must be specified on every EFFECT card to indicate the number of levels (sample size) for each particular facet.

NPOPUL is an optional user-supplied integer value specifying the population or universe size for each particular facet. A value of zero implies that the universe size is infinite, and the default value, if NPOPUL is not specified, is zero ==> infinity. To specify a fixed effect, NUMLEV and NPOPUL would be specified as the same value.

The PROCESS card signals the end of the control cards for a particular study and indicates that processing of the data should commence. If a value for KDATA is specified in columns 13-80, the data will be read from that logical unit number, otherwise it will

be read from the default input logical unit = 5. Because data may follow the PROCESS card, it can have no continuations.

FORMAT Card, COMMENT Card and OPTIONS Card

The FORMAT card specifies the run-time FORTRAN format that will be used to read the input data. The object-time format, KFORM, is specified starting in columns 13-80 of the FORMAT card and can have up to two continuations for a total size of 68 x 3 = 204 characters. The object-time FORTRAN format must be enclosed within parentheses.

The COMMENT card provides the GENOVA user with a method of inserting additional notes or information about the study or the data set into the control card listing printed out by GENOVA. These cards are not processed by GENOVA other than to print them out as they are encountered.

The OPTIONS card allows the user to alter several default output options of GENOVA by specifying the appropriate parameters in the data area (columns 13-80) of this card and its continuations (if any).

One GENOVA output option that the user may want to change is the default number of input records to be printed out = first and last ten. This is accomplished by specifying a 'RECORDS' parameter followed by one of three parameters:

'ALL'	--	meaning to print out all input records;
'NONE'	--	meaning to suppress printing of input records; or
NREC	--	an integer value indicating that the first and last 'NREC' input records are to be printed.

The input records are printed out with: (a) sequence number of the record; (b) each of the values in the record; and (c) the mean of these values. The 'RECORDS' output option is initially defaulted to ten unless reset by an OPTIONS card.

The 'CORRELATION' parameter on an OPTIONS card specifies that the correlation matrix of estimated variance components is to be printed out for the current study. The default is not to print out this matrix.

FINISH Card

The FINISH card indicates that GENOVA execution will cease, and should always be the last GENOVA control card encountered.

Two sample data sets and designs will be discussed in this chapter to illustrate the basics of the GENOVA system.

FIGURE 2.1

Control Cards for Simple Run No. 1

```
Columns  111111111122222222223333333333444444444455555555556666666
         123456789012345678901234567890123456789012345678901234567890123 45
```

```
STUDY        DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1
COMMENT
COMMENT      # RECORDS = 10
COMMENT      # VALUES PER RECORD = 12
COMMENT
OPTIONS      RECORDS ALL   CORRELATION
EFFECT       * P 10 0
EFFECT       + T 3 0
EFFECT       + I:T 4 0
FORMAT       (12F2.0)
PROCESS
 5 6 5 5 5 3 4 5 6 7 3 3
 9 3 7 7 7 5 5 5 7 7 5 2
 3 4 3 3 5 3 3 5 6 5 1 6
 7 5 5 3 3 1 4 3 5 3 3 5
 9 2 9 7 7 7 3 7 2 7 5 3
 3 4 3 5 3 3 6 3 4 5 1 2
 7 3 7 7 7 5 5 7 5 5 5 4
 5 8 5 7 7 5 5 4 3 2 1 1
 9 9 8 8 6 6 6 5 5 8 1 1
 4 4 4 3 3 5 6 5 5 7 1 1
FINISH
```

Simple Run No. 1 Control Cards and Data

The first sample design is a **P X (I:T)** design with all random effects. Figure 2.1 shows the complete set of control cards necessary to analyze the data for this study by GENOVA, and Appendix B provides the output resulting from this run.

The first control card is a 'STUDY' card which provides two kinds of information:

1. Columns 13 through 80 are used as a heading for all report pages for this study.
2. The STUDY control card also signifies the start of a series of control cards to define the ANOVA to be performed.

The 'COMMENT' cards which follow next simply show the data set and its structure. COMMENT cards are simply printed out by GENOVA and otherwise have no effect.

The 'OPTIONS' card which follows the COMMENT cards sets two output options for GENOVA:

1. The 'RECORDS ALL' parameters on the OPTIONS card specify that all input records are to be printed out with their respective record means. The default is to print out only the first and last 10 records. A record is defined as all data that pertains to a single level of the starred facet. (Sometimes the starred facet is a person, an experimental animal or an agricultural plot).
2. The 'CORRELATION' parameter specifies that the correlation matrix of estimated variance components be printed out. The default is not to print out this matrix.

The three 'EFFECT' control cards which follow the OPTIONS card provide the detailed information to GENOVA about the three facets of this design.

On the first EFFECT card, the four parameters provide the following information:

1. The '*' indicates that this is the 'STARRED' facet or record facet.
2. The 'P' indicates that the letter which is being used to describe this facet will be 'P'.
3. The '10' indicates that the number of observations for 'P' (or the sample size) is ten.
4. The '0' indicates an infinite universe was available to sample or draw observations from; i.e. 'P' is a random effect. Since the default universe is infinite, there would have been no change if the zero parameter had been left off of this EFFECT card.

The four parameters on the second EFFECT card provide the following information:

1. The '+' signifies that cell means will be printed for all main and interaction effects which contain only 'T' and other facet characters which were preceded by a '+' on their respective EFFECT cards.
2. The 'T' indicates that the letter 'T' is being used to denote the second facet.
3. The '3' indicates that there will be three observations on 'T' for each observation on 'P'.
4. The '0' indicates that 'T' is a random effect, i.e. was sampled from an infinite universe.

The four parameters on the third EFFECT card provide the following information:

1. The '+' signifies the same requirement for cell means printing for 'I' as the '+' on the previous card signified for 'T'. Since 'T' and 'I:T' are the only effects in this study which contain only 'I' and/or 'T', cell means will

be printed out for only the effects 'T' and 'I:T.' (As will be evident later, the set of effects for this design is P, T, I:T, PT, and PI:T.)

2. The 'I:T' signifies that 'I' will be used to denote the third facet and that 'I' is nested within 'T'.
3. The '4' indicates that there will be four observations on 'I' for each observation on 'T'.
4. The 'Ø' indicates that 'I' is a random effect; that is, that it was sampled from an infinite universe.

The 'FORMAT' card, starting in column 13, specifies the format of the data to be read by GENOVA to perform the analysis of variance.

The 'PROCESS' card signals that all control cards for this study have been read and the processing can start. Since no parameter appeared on the PROCESS card (blank in columns 13-8Ø), GENOVA assumes that the data immediately follow the PROCESS card on the input logical unit (default = 5). If an integer parameter appears in the data area of the PROCESS card, e.g. '7', GENOVA would read the data from that logical unit number.

Output for Simple Run No. 1

Appendix B (pp. B-2 to B-7) provides the output produced by GENOVA using the control cards and input data matrix in Figure 2.1.

Title Page and Control Card Listing

The first output is a Title Page for the program (B-2). The second page (top of B-3) provides a listing of all control cards read and processed by GENOVA up to the PROCESS card.

Expanded Main and Interaction Effect Table

The bottom part of B-3 contains the first output from GENOVA for this study, the expanded main and interaction effect table. The heading on the second line comes directly from the STUDY control card.

The table has one row for each facet (main effect) and for each interaction effect. There is one column for each facet character, in this case **P**, **T** and **I**. A zero in the table indicates that the facet character (index) in that column does not enter into the facet or interaction effect in that row. A one in the table indicates that the index in that column enters into the effect in that row, and that the index occurs before any ":", if present. (These are called "primary indices" later in this manual.) A two in the table indicates that the index in that column enters into the effect for that row, and that the index occurs after the first ":".

If a three occurred in the table, it would indicate that the index in that column entered into the effect for that particular

row, and that the index occurred after the second ":". E.g., for A:B:C, there would be a 3 under the column headed "C". Only values Ø through 5 can occur in this table.

The three rows above the table provide the facet character and the corresponding sample and universe size for each facet.

The first column to the right of the table indicates the number of primary indices (indices that occur before any colon) which occur in each effect, and the second column to the right indicates the total number of indices or facets which enter into each effect.

The last column to the right of the table specifies the degrees of freedom that are associated with each main and interaction effect.

This table and the accompanying data are used extensively throughout GENOVA as a basis for processing and printing of results.

Input Record Listing with Record Means

Page B-4 shows the output produced by the 'RECORDS ALL' parameter from the OPTIONS card: the listing of each input record's sequence number, the input record itself (12 values) followed by the input record mean (the thirteenth or last value printed for each record). Note again that the heading comes directly from the STUDY card. The same heading will appear on each of the output reports for this entire study.

Cell Mean Scores

The top part of B-5 shows the output generated due to the use of the '+' optional parameter on the 'T' and 'I:T' EFFECT cards. The grand mean is printed, along with the cell means for all effects which contain only 'I' and 'T' facets.

Sums of Squares, Mean Squares and F-Statistics

The initial results of the ANOVA for this example are shown on the bottom of B-5. Once again the results are organized by rows for each of the effects in the study, with two additional rows for "MEAN" and "TOTAL" values.

The degrees of freedom for each effect are again displayed along with the total degrees of freedom shown on the last row of this report.

The third column reports the values for the 'sums of squares for mean scores' for each effect and for the mean (in the next to the last row). The sums of squares for mean scores is what Brennan (1983) and others refer to as T-terms. (Note that this use of the letter 'T' should not be confused with the use of 'T' as a facet in this run of GENOVA.)

The next column reports the 'sums of squares for score effects' for each effect, or more commonly the sums of squares (SS) from an ANOVA.

The fifth column contains the standard mean squares (MS) calculated for each effect in the model.

The last three columns in B-5 report the F-statistic with the associated degrees of freedom whenever it is calculable. If the characters 'QF' follow these values in a particular row, this implies that a Quasi-F statistic has been calculated (see, for example, Kirk, 1968, pp. 212-214).

Quasi-F statistics are reported only when the calculation does not become too complex. Care should be exercised in using the Quasi-F values, as the degrees of freedom can sometimes be zero (which is meaningless) using the formulas from Kirk.

Estimated Variance Components and Standard Errors

The output at the top of B-6 reports two sets of 'estimated variance components' and the 'standard errors' of the first set of estimates.

The first set of variance components, denoted as "USING ALGORITHM," are calculated by applying the standard matrix formulae (see Brennan, 1983, p.133):

EMS = P*VC
and
EVC = PINV*MS

EMS means 'expected mean squares,' VC means 'variance components,' P represents the upper triangular matrix of EMS equation coefficients and PINV is the inverse matrix of 'P.' MS stands for the column vector of 'mean square' values and EVC is the resulting column vector of 'estimated variance components' for the design being processed. The EVC values are those that are reported under the 'USING ALGORITHM' column.

The second column of estimated variance components is generated from the first column using the EMS equations to recalculate the variance components, replacing any negative estimates by zero (see Cronbach et al., 1972, pp. 57-58). If there are no negative estimates, these two columns will be identical.

Standard Errors

The last column provides standard errors for each of the estimated variance components (see Searle, 1971, pp. 417 ff.). No standard error is reported for an effect that involves only fixed facets, but this is not an issue for this first example because all effects are random.

Expected Mean Square Equations

The 'expected mean square equations' are printed out by GENOVA for each study, as shown on the bottom of B-6 for this simple run.

Variance-Covariance Matrix

The 'variance-covariance matrix of estimated variance components' shown at the top of B-7 for this example is the final standard GENOVA report for an ANOVA study run. (See Brennan, 1983, p. 133 for the procedure used to estimate the variance-covariance matrix.) It should be noted that effects whose facets are all fixed do not appear in the matrix printed out by GENOVA. This is not an issue for this first example since all the effects are random.

Correlation Matrix for Estimated Variance Components

The correlation matrix for estimated variance components, shown at the bottom of B-7 for this simple run, is not a standard GENOVA report, but is only produced when the 'CORRELATION' parameter is used on an OPTIONS card.

The last page of the GENOVA execution output for Simple Run No. 1 is shown on B-7, listing the final control card, FINISH.

Simple Run No. 2 Control Cards, Data and Results

The control cards and data for Simple Run No 2 are shown in Figure 2.2 and the results are shown in Appendix B (B-8 through B-13). This ANOVA sample study, with a design of **S:(ABC)**, is taken from Kirk (1968, p. 219).

There are several essential differences between this simple run and the previous one, ignoring the different designs and data sets.

First of all, the second example does not contain an OPTIONS card. Therefore the defaults will apply, and GENOVA will print out the first and last ten input records with their record means. To have all the input records printed, an OPTIONS card with the 'RECORDS ALL' parameter would have to be added. The absence of an OPTIONS card also means that the correlation matrix of estimated variance components will not be printed since this is an optional report and must be selected on an OPTIONS card as it was in the first example.

The second difference between the two examples is that for this study, the 'starred' facet is the last one specified to GENOVA. This means that there will be exactly one value (observation) for each input record. The listing of input records with means (shown on B-9) therefore decomposes to a two-column listing of the input record value and the identical record mean.

The third major difference in this second example is that two of the four facets are fixed, that is, there is no random sampling involved. Fixed facets affect the GENOVA reports in several different ways:

1. The estimated variance components for **B**, **C** and the interaction effect **BC** are all printed (B-12 top) with 'QFM' following the two esitmates for each effect. This indicates that these values are quadratic forms because the effects are fixed.
2. The standard error columns for these three fixed effects are all blank since there is no sampling to contribute to a standard error value.
3. The variance-covariance matrix (B-13 top) is also altered by the presence of fixed effects in that rows and columns associated with effects involving only fixed facets are excluded from the matrix printed. As can be seen on B-13, there are no entries for the rows and columns associated with **B**, **C** or **BC** effects.
4. If the correlation table had been printed for this study, it would also be lacking entries for these three rows and columns.

FIGURE 2.2

Control Cards for Simple Run No. 2

```
Columns  1111111111222222222233333333334444444444555555555566666666
         1234567890123456789012345678901234567890123456789012345678901234567890123456
STUDY        DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 2
COMMENT
COMMENT      # RECORDS = 32
COMMENT      # VALUES/RECORD = 1
COMMENT
EFFECT       + A 2 Ø
EFFECT       + B 2 2
EFFECT       + C 2 2
EFFECT       * S:ABC 4 Ø
FORMAT       (F3.Ø)
PROCESS
  3
  6
  3
  3
  4
  5
  4
  3
  7
  8
  7
  6
  7
  8
  9
  8
  1
  2
  2
  2
  2
  3
  4
  3
  5
  6
  5
  6
 1Ø
 1Ø
  9
 11
FINISH
```

CHAPTER 3

DECISION (D) STUDIES

In addition to G study analyses as described in Chapter 2, GENOVA also provides D (Decision) study analyses. In general terms, a D study focuses on the estimation, use and interpretation of variance components for decision-making. D studies may, in practice, involve the collection of new data, however, most D studies use the data (or a subset) from a previous G study. GENOVA does not support the collection of new data for a D study analysis, but does support most other D study considerations as described in Brennan (1983).

If a GENOVA user wants only G study results, then no D study control cards are required. If D study analyses are desired, however, then there should be one set of D study control cards for each design structure and/or universe of generalization (see Brennan, 1983).

Figure 3.1 shows a typical set of GENOVA control cards to perform one G study followed by multiple D studies.

A set of D study control cards consists of a **DSTUDY** card, a set of **DEFFECT** cards, an optional **DCUT** card, and an **ENDDSTUDY** card that terminates a D study set of control cards.

Consider the following set of D study control cards from Figure 3.1:

```
DSTUDY      #3 -- P X (I:R) -- I - RANDOM, R - FIXED
DEFFECT     $ P
DEFFECT       R 3 / 3
DEFFECT       I:R 1 2 3 4
ENDDSTUDY
```

DSTUDY Card

The DSTUDY card signifies the start of a set of D study control cards. The text in columns 13-80 of the DSTUDY card will be used as a title for D study printed output.

The DSTUDY control card must follow a GSTUDY (STUDY) run of GENOVA or a GCOMPONENTS or GMEANSQUARES (see Chapter 4) GENOVA run.

FIGURE 3.1

Sample Control Card Input for D Study Analyses

```
COLUMN    1111111111222222222233333333334444444444555555555566666
1234567890123456789012345678901234567890123456789012345678901234
```

```
GSTUDY        P X (I:R) DESIGN -- RANDOM MODEL
OPTIONS       RECORDS 2
EFFECT        * P 10 0
EFFECT        + R  3 0
EFFECT        + I:R 4 0
FORMAT         (12F2.0)
PROCESS
 5 6 5 5 5 3 4 5 6 7 3 3      PERSON  1
 9 3 7 7 7 5 5 5 7 7 5 2      PERSON  2
 3 4 3 3 5 3 3 5 6 5 1 6      PERSON  3
 7 5 5 3 3 1 4 3 5 3 3 5      PERSON  4
 9 2 9 7 7 7 3 7 2 7 5 3      PERSON  5
 3 4 3 5 3 3 6 3 4 5 1 2      PERSON  6
 7 3 7 7 7 5 5 7 5 5 5 4      PERSON  7
 5 8 5 7 7 5 5 4 3 2 1 1      PERSON  8
 9 9 8 8 6 6 6 5 5 8 1 1      PERSON  9
 4 4 4 3 3 5 6 5 5 7 1 1      PERSON 10
COMMENT       FIRST SET OF D STUDY CONTROL CARDS
DSTUDY        #1 -- P X (I:R) DESIGN -- I,R - RANDOM
DEFFECT       $ P
DEFFECT         R 3
DEFFECT         I:R 1 2 3 4
ENDDSTUDY
COMMENT       SECOND SET OF D STUDY CONTROL CARDS
DSTUDY        #2 -- I:R:P DESIGN -- I,R - RANDOM
DCUT                   0.2 0.4 0.6 0.8 1.0
DEFFECT       $ P
DEFFECT         R:P 3
DEFFECT         I:R:P 1 2 3 4
ENDDSTUDY
COMMENT       THIRD SET OF D STUDY CONTROL CARDS
DSTUDY        #3 -- P X (I:R) -- I - RANDOM, R - FIXED
OPTIONS       DTABLE
DEFFECT       $ P
DEFFECT         R 3 / 3
DEFFECT         I:R 1 2 3 4
ENDDSTUDY
FINISH
```

DEFFECT Cards

The DEFFECT control cards describe the design, sample sizes, object of measurement, and the universe of generalization for the D study. The DEFFECT cards are analagous to the EFFECT cards for a G study, in that there is one DEFFECT card for each main effect in a D study design. There is no restriction, however, on the ordering of the DEFFECT cards in the control card setup.

The general format of the data area (columns 13-80) of each DEFFECT card is:

[$] DFACET [ISAMPD (1-30)] [/ IUNIVD]

where brackets indicate optional parameters.

DFACET is the character string of letters and colons that describe a facet in the D study design.

The '$' parameter must appear on exactly one of the DEFFECT cards and indicates that this main effect (facet) will be the object of measurement for the D study analysis. The '$' must be the first parameter in the data area of the DEFFECT card it appears on.

Note: GENOVA does not allow the object of measurement to be nested, i.e. the DFACET parameter which follows a "$" cannot contain a colon.

ISAMPD is a set of from one to 30 sample sizes for the DFACET facet. If ISAMPD is not specified, GENOVA uses the sample size from the G study.

IUNIVD is the population or universe size for this facet. If no value is specified for IUNIVD, GENOVA uses the population or universe size from the G study.

Sample Size Interactions

As noted above, more than one sample size (ISAMPD) may be specified on each DEFFECT card. A separate set of D study results will be provided for each sample size specified. The number of D study results produced from a single set of D study control cards will equal the largest number of ISAMPD values specified on any DEFFECT card.

It is not necessary to have the same number of sample size (ISAMPD) values on each DEFFECT card since GENOVA will simply extend the last (or default) sample size specified for a facet as many times as necessary (up to thirty total). Consider the following set of DEFFECT cards:

```
DEFFECT     $  P

DEFFECT        R  3 6 9

DEFFECT        I:R 1 2 3 4 5
```

where the sample size for P in the G study was 10. These DEFFECT cards would have exactly the same effect as the following DEFFECT cards:

```
DEFFECT     $ P 10 10 10 10 10

DEFFECT        R  3  6  9  9  9

DEFFECT       I:R 1  2  3  4  5
```

For the first set of DEFFECT Cards, the largest number of sample sizes is five. The default (from the G study) sample size of 10 for "P" is logically extended five times and the last (third) sample size for "R" (9) is logically extended two more times when processing starts for this D study. Therefore the second set of DEFFECT cards would have exactly the same effect as the first set.

ENDDSTUDY Card

The ENDDSTUDY control card completes the D study set of control cards and initiates the GENOVA D study processing.

DCUT CARD

The DCUT card is an optional D study control card which may be present whenever a D study set of control cards is being processed, and may appear anywhere between a DSTUDY card and an ENDSTUDY cards. If a DCUT card is encountered during a D study, optional output involving cutting scores (see Brennan, 1983, pp 108,109) will be produced.

Specifying Cutting Scores

If the data area (columns 13-80) of the DCUT card is blank or contains the parameter **'STANDARD'** then a standard (default) set of eleven cutting scores will be used:

0.0, 0.1, 0.2, ... 0.9, 1.0

Optionally, the user may specify his/her own set of cutting scores (up to thirty) in the data area of the DCUT card in FORTRAN F-format (with decimal point).

Note: The optional D study cutting score analysis requires the existence of a grand mean from the previous G study. If the D study being processed follows a GMEANSQUARES or GCOMPONENTS execution of GENOVA (see Chapter 4), no grand mean is available

and its value must be provided for the DCUT analysis to take place. See discussions in APPENDIX A on the DCUT, ENDDSTUDY, ENDCOMP and ENDMEAN control cards for an explanation of how the grand mean value can be specified to GENOVA.

D Study OPTIONS Card Parameters

There are three OPTIONS card parameters that affect the GENOVA processing and/or output of D studies.

The first two parameters are 'EMS' and 'ALGORITHM.' They specify which estimated variance components from the previous G study are to be used in D study processing. The default is EMS (Expected Mean Squares) estimated variance components.

The third OPTIONS card parameter, 'DTABLE,' will provide an optional D study variance-covariance output matrix described in Brennan, 1983, Appendix C.

D Study Output

Part of the output produced by the GENOVA control cards and data in Figure 3.1 is included in Appendix C.

Page C-1 presents an abbreviated index to Appendix C.

Pages C-2 and C-3 show part of the results of the initial G study.

Page C-4 shows the GENOVA control card listing for control cards and the last D study analysis for the first set of D study control cards from Figure 3.1.

Page C-5 shows the summary table for the first set of D study control cards.

Page C-6 shows the GENOVA control card listing for control cards and the last D study analysis for the second set of D study control cards plus the optional cutting score analysis.

Page C-7 shows the summary table for the second set of D study control cards.

Page C-8 shows the GENOVA control card listing for control cards and the last D study analysis for the third set of D study control cards. (Note the DTABLE parameter on the OPTIONS card.)

Page C-9 shows the optional variance-covariance D study output (see Brennan, 1983, Appendix C) and the summary table for the third set of D study control cards.

CHAPTER 4

OTHER FEATURES OF GENOVA AND TECHNICAL CONSIDERATIONS

Chapter 2 of this manual discusses simple runs of GENOVA based upon using only those control cards and parameters listed in Table 2.1 and discussed in Chapter 2. There are other features and facilities of GENOVA which result from using other control cards and/or parameters described extensively in Appendix A. In most cases, these additional features are the subject of the first several sections of Chapter 4. The remaining sections treat computer-related technical considerations relevant to modifying and/or running GENOVA. Throughout this chapter, it is assumed that readers have studied Appendix A, and that they have more than minimal familiarity with analysis of variance and computers.

Other Features

Using Mean Squares as Input

It sometimes occurs that a researcher already has the mean squares for a study from some other computer program or from the published results of the study. It is possible to produce the complete range on GENOVA analysis reports (excluding input record listings, cell means and sums of squares) with only mean square values as input using the **GMEANSQUARES, MEANSQUARE** and **ENDMEAN** control cards.

The GMEANSQUARES control card initiates a GENOVA run using mean squares as input in the same manner that a STUDY card initiates a GENOVA run using raw data, including the heading from columns 13-80. A run initiated by a STUDY card, however, is completed by a PROCESS card while a GMEANSQUARES run of GENOVA is completed by an ENDMEAN control card. The only additional control cards required for mean squares input is a set of MEANSQUARE control cards, one for each main effect (or facet) and each interaction effect in the study's design. OPTIONS and COMMENT cards may also be used between the GMEANSQUARES and the ENDMEAN cards.

There are two formats for the MEANSQUARE cards as described in Appendix A:

MEANSQUARE MFACET XMSQR NSAMP [NUNIV]

MEANSQUARE MEFFCT XMSQR

As discussed in Appendix A, MFACET is a character string, XMSQR is a real variable (F format) and NSAMP and NUNIV are integer values.

The first format is used for each of the main effects (or facets) of the design (maximum of 6) and must all be entered before

the second format MEANSQUARE cards, one for each interaction effect. The only restriction on the input order of the format 1 MEANSQUARE cards is that a nested facet must be specified after the facets within which it is nested; i.e. **T** must be entered before **I:T**, and **A**, **B** and **C** must be entered before **S:ABC.**

Figure 4.1 shows a GENOVA control card setup for mean squares input using the results from Simple Run No. 2 in Appendix B (bottom B-12). Note that in Figure 4.1 the model is defined as random, rather than mixed. Figures 4.2 and 4.3 show part of the output produced by this GMEANSQUARES run of GENOVA.

FIGURE 4.1

Sample Control Cards for Mean Squares Input

```
Columns  111111111122222222223333333333444444444455555555556666666
         123456789012345678901234567890123456789012345678901234567890123456789012345
```

```
GMEANSQUARES MEAN SQUARES INPUT - S:(AXBXC) DESIGN - RANDOM MODEL
COMMENT
COMMENT      FORMAT 1 MEAN SQUARES FOR EACH FACET
COMMENT
MEANSQUARE   A      3.125 2
MEANSQUARE   B    162.    2
MEANSQUARE   C     24.5   2
MEANSQUARE   S:ABC  .7708333 4
COMMENT
COMMENT      FORMAT 2 MEAN SQUARES FOR EACH INTERACTION EFFECT
COMMENT
MEANSQUARE   ABC     3.125
MEANSQUARE   AB      6.125
MEANSQUARE   AC     10.125
MEANSQUARE   BC      8.
ENDMEAN
FINISH
```

CONTROL CARD INPUT LISTING

```
COLUMN    1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
GMEANSQUARES MEAN SQUARES INPUT - S:(AXBXC) DESIGN - RANDOM MODEL
COMMENT
COMMENT     FORMAT 1 MEAN SQUARES FOR EACH FACET
COMMENT
MEANSQUARE  A         3.125 2
MEANSQUARE  B       162.    2
MEANSQUARE  C        24.5   2
MEANSQUARE  S:ABC      .7708333 4
COMMENT
COMMENT     FORMAT 2 MEAN SQUARES FOR EACH INTERACTION EFFECT
COMMENT
MEANSQUARE  ABC       3.125
MEANSQUARE  AB        6.125
MEANSQUARE  AC       10.125
MEANSQUARE  BC        8.
ENDMEAN
```

G STUDY — MEAN SQUARES INPUT - S:(AXBXC) DESIGN - RANDOM MODEL
ANOVA TABLE

(** = INFINITE)	A	B	C	S
SAMPLE SIZE	2	2	2	4
UNIVERSE SIZE	****	****	****	****

(QF = QUASI F RATIO)

EFFECT	DEGREES OF FREEDOM	SUMS OF SQUARES FOR MEAN SCORES	SUMS OF SQUARES FOR SCORE EFFECTS	MEAN SQUARES	F STATISTIC	F-TEST DEGREES OF FREEDOM NUMERATOR	DENOMINATOR
A	1	----------	----------	3.12500	0.23810 QF	1 QF	1 QF
B	1	----------	----------	162.00000	14.72727 QF	1 QF	1 QF
C	1	----------	----------	24.50000	1.63333 QF	1 QF	1 QF
S:ABC	24	----------	----------	0.77083			
AB	1	----------	----------	6.12500	1.96000	1	1
AC	1	----------	----------	10.12500	3.24000	1	1
BC	1	----------	----------	8.00000	2.56000	1	1
ABC	1	----------	----------	3.12500	4.05405	1	24
TOTAL	31						

NOTE: FOR GENERALIZABILITY ANALYSES, F-STATISTICS SHOULD BE IGNORED

FIGURE 4.2

Control Card Listing and Study Results for Mean Squares Input

G STUDY — MEAN SQUARES INPUT - S:(AXBXC) DESIGN - RANDOM MODEL
G STUDY RESULTS

(** = INFINITE)	A	B	C	S
SAMPLE SIZE	2	2	2	4
UNIVERSE SIZE	****	****	****	****

QFM = QUADRATIC FORM

EFFECT	DEGREES OF FREEDOM	MODEL VARIANCE COMPONENTS USING ALGORITHM	USING EMS EQUATIONS	STANDARD ERROR
A	1	(0.0)	(0.0)	0.6446141
B	1	9.4375000	9.4375000	8.2845365
C	1	0.5937500	0.5937500	1.4220467
S:ABC	24	0.7708333	0.7708333	0.2137907
AB	1	0.3750000	0.3750000	0.7017927
AC	1	0.8750000	0.8750000	1.0814788
BC	1	0.6093750	0.6093750	0.8765797
ABC	1	0.5885417	0.5885417	0.6401232

NOTE: THE "ALGORITHM" AND "EMS" ESTIMATED VARIANCE COMPONENTS WILL BE IDENTICAL IF THERE ARE NO NEGATIVE ESTIMATES

G STUDY — MEAN SQUARES INPUT - S:(AXBXC) DESIGN - RANDOM MODEL
VARIANCE - COVARIANCE MATRIX FOR ESTIMATED VARIANCE COMPONENTS (V)

	A	B	C	AB	AC	BC	ABC	S:ABC
A	0.4155273							
B	0.1231283	68.6335449						
C	0.2923991	0.1920980	2.0222168					
AB	-0.2462565	-0.2462565	-0.0508626	0.4925130				
AC	-0.5847982	-0.0508626	-0.5847982	0.1017253	1.1695964			
BC	-0.0508626	-0.3841960	-0.3841960	0.1017253	0.1017253	0.7683919		
ABC	0.1017253	0.1017253	0.1017253	-0.2034505	-0.2034505	-0.2034505	0.4097577	
S:ABC	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	-0.0114266	0.0457065

FIGURE 4.3

Variance Components, Standard Errors and
Variance-Covariance Matrix for Mean Square Input

Using Variance Components as Input

Variance components from a previous study may also be used as input to GENOVA by using **COMPONENTS**, **VCOMPONENT** and **ENDCOMP** control cards. These three control cards have the same format and functions as the GMEANSQUARES, MEANSQUARE and ENDMEAN cards just described except that values for variance components are provided on the VCOMPONENT cards rather than values for mean squares on the MEANSQUARE cards.

In using variance components as input, it is important to note that the GENOVA output is highly dependent upon the user-specified sample and population (or universe) sizes. The GENOVA output will be meaningless unless the sample and population sizes are those used in obtaining the estimated variance components. Furthermore, there must be a VCOMPONENT card for each effect in the full model, and each such card must contain an estimated variance component or quadratic form. (Whenever fixed facet(s) is (are) present, there will be at least one quadratic form that "takes the place of" an estimated variance component.)

A GCOMPONENTS run of GENOVA produces less output than a STUDY or GMEANSQUARES run simply because the variance components are already known. What GENOVA does generate are (1) the expanded main and interactions effects table, (2) standard errors, (3) the EMS equations, (4) the variance-covariance matrix and, optionally, (5) the correlation matrix of estimated variance components.

Figure 4.4 shows the control cards for inputting the estimated variance components from Simple Run No. 1, and Figure 4.5 shows the GENOVA control card listing for this run and the unique table produced by GENOVA for variance components input, listing the input data and reporting the standard errors. The other tables produced by this run of GENOVA would be essentially identical to those shown in Appendix B for this simple study.

FIGURE 4.4

Sample Control Cards for Variance Components Input

```
Columns  1111111111222222222233333333334444444444555555555566666666
12345678901234567890123456789012345678901234567890123456789012345
```

```
GCOMPONENTS VARIANCE COMPONENTS INPUT - P X (I:T) - RANDOM MODEL
COMMENT
COMMENT     FORMAT 1 VAR. COMPONENTS FOR EACH FACET
COMMENT
VCOMPONENT  P      0.4731481 10
VCOMPONENT  T      0.3251543 3
VCOMPONENT  I:T    0.6475309 4
COMMENT
COMMENT     FORMAT 2 VAR. COMPONENTS FOR EACH INTERACTION EFFECT
COMMENT
VCOMPONENT  PT     0.5595679
VCOMPONENT  PI:T   2.3802469
ENDCOMP
FINISH
```

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
GCOMPONENTS VARIANCE COMPONENTS INPUT - P X (I:T) - RANDOM MODEL
COMMENT
COMMENT     FORMAT 1 VAR. COMPONENTS FOR EACH FACET
COMMENT
VCOMPONENT  P     0.4731481 10
VCOMPONENT  T     0.3251543 3
VCOMPONENT  I:T   0.6475309 4
COMMENT
COMMENT     FORMAT 2 VAR. COMPONENTS FOR EACH INTERACTION EFFECT
COMMENT
VCOMPONENT  PT    0.5595679
VCOMPONENT  PI:T  2.3802469
ENDCOMP
```

G STUDY

VARIANCE COMPONENTS INPUT - P X (I:T) - RANDOM MODEL
DATA INPUT FOR GCOMPONENTS RUN -- AND STANDARD ERRORS

EFFECT	DEGREES OF FREEDOM	SAMPLE SIZE	M O D E L UNIVERSE SIZE	VARIANCE COMPONENTS	STANDARD ERROR
P	9	10	****	0.4731481	0.3855758
T	2	3	****	0.3251543	0.4379875
I:T	9	4	****	0.6475309	0.3794056
PT	18			0.5595679	0.3766290
PI:T	81			2.3802469	0.3694860
TOTAL	119				

FIGURE 4.5

Partial Output for Variance Components Input

Additional OPTIONS Card Parameters

There are two additional OPTIONS card parameters that were not discussed in Chapter 2:

[NEGATIVE] and **[RESET]**

The 'NEGATIVE' parameter specifies that whenever negative estimates for variance components occur, the negative values should be printed. The default in GENOVA is to print '(Ø.Ø)' whenever negative estimates occur.

The 'RESET' parameter is used to reset all OPTIONS card parameters back to their default values. This parameter is necessary because multiple runs (STUDY, GMEANSQUARES and GCOMPONENTS) can be processed in a single execution of GENOVA. The RESET parameter provides the facility to bring the default output options back into effect for any GENOVA run, regardless of any options that may have been previously in effect.

Other OPTIONS card parameters may follow the RESET parameter on the same card to change the output options for a particular run or study. See Appendix A for a more detailed discussion of all OPTIONS card parameters.

Altering the Output Logical Unit

The **OUTPUT** control card gives the GENOVA user the facility to specify an alternate logical unit number for the GENOVA reports to be printed on. The OUTPUT card can have exactly one parameter in the data area (columns 13-8Ø) of the card and this must be an integer value representing the logical unit number to be used for output. The default output logical unit number is **6**. The user must insure that the appropriate job control statement is used whenever the OUTPUT card is used.

Specifying Descriptions for Facets in a STUDY Run

The **NAME** card is an optional control card that can appear in a STUDY (or GSTUDY) run of GENOVA to produce an optional table providing descriptive information about the facets included in the current study. The format of the NAME card is:

NAME MCHAR "MNAME"

where 'MCHAR' is a single character representing a facet that has already be specified on an EFFECT card, and 'MNAME' is a description of this facet enclosed in double quote marks.

The NAME cards may appear anywhere between the STUDY card and the PROCESS card as long as they follow the EFFECT card that specifies their respective facet. The top of Figure 4.6 shows a sample GENOVA study control card listing which includes NAME cards

for each facet, and the bottom part of Figure 4.6 shows the output produced by GENOVA when NAME cards are used.

Specifying Subheadings for Reports

The **SUBHEADING** control card gives the GENOVA user the ability to specify an optional sub-heading to appear on every page of a GENOVA analysis in addition to the heading which is provided on a GSTUDY, STUDY, GMEANSQUARES or GCOMPONENTS card. The sub-heading is taken from columns 13-80 of the SUBHEADING card and remains in effect until a GSTUDY, STUDY, GMEANSQUARES or GCOMPONENTS card is encountered. The default for each of these three runs is no sub-headings unless the optional SUBHEADING card is specified.

Figure 4.6 shows a sample use of the SUBHEADING card and the output that it generates.

Rewinding Logical Units

GENOVA users have the facility to rewind one or more logical units via the **REWIND** control card. The data area of the REWIND card may contain one or more positive integer constants representing the logical units to be rewound.

The most common application of the REWIND card is to make multiple GENOVA analysis runs against the same data set using different models. The first study will simply read the data by specifying a logical unit on the PROCESS card, but subsequent GSTUDY or STUDY runs in the same execution would have to rewind the logical unit containing the data set before processing starts. Figure 4.7 shows a typical series of GENOVA studies referencing the same data set located on logical unit 7. Figures 4.8 and 4.9 also illustrate the use of the REWIND card in conjunction with the READ and REVERT cards to be discussed next.

Note that the various runs in Figures 4.7 and 4.8 involve analyzing the same data according to different designs (the p x i design, the i:p design, etc.). In providing these illustrations we are not suggesting that one ought to analyze data according to different designs; we are simply illustrating a feature of GENOVA.

There are some restrictions on the logical unit numbers which can be rewound (e.g. the logical input and output units). See Appendix A for a complete discussion of the REWIND card and its restrictions.

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
GSTUDY                CYNDIE'S DATA SET
SUBHEADING      P: [R X (V:S)] X T
EFFECT              + R   2   2
OPTION             RECORDS 20
EFFECT          + S     2    2
EFFECT        + V:S      2   0
EFFECT      *   P:RV:S        146   0
EFFECT           + T       5      5
NAME           R  "RACE"
NAME            S   "TYPE OF UNIT"
NAME            V "UNIT WITHIN TYPE OF UNIT"
NAME           P   "PERSONS"
NAME           T    "TYPE OF ITEM"
FORMAT      (40X,5F4.1)
PROCESS       7
```

```
G STUDY                                        CYNDIE'S DATA SET
          SUB HEADING:                         P: [R X (V:S)] X T

          LISTED BELOW ARE THE USER-SUPPLIED NAMES THAT
          THE RESPECTIVE MAIN EFFECT CHARACTERS IN THIS
          STUDY REPRESENT.

 MAIN
 EFFECT
 CHARACTER  USER-SUPPLIED NAME

*****************************************************************************
*                                                                           *
*                                                                           *
*   R       RACE                                                            *
*                                                                           *
*                                                                           *
*   S       TYPE OF UNIT                                                    *
*                                                                           *
*                                                                           *
*   V       UNIT WITHIN TYPE OF UNIT                                        *
*                                                                           *
*                                                                           *
*   P       PERSONS                                                         *
*                                                                           *
*                                                                           *
*   T       TYPE OF ITEM                                                    *
*                                                                           *
*                                                                           *
*****************************************************************************
```

FIGURE 4.6

Sample GENOVA Output with 'NAME' and 'SUBHEADING' Control Cards

FIGURE 4.7

Sample GENOVA Runs Using the REWIND Card

```
Columns  1111111111222222222233333333334444444444555555555566666
         1234567890123456789012345678901234567890123456789012345678901234
```

```
GSTUDY      D. SET 3 - RANDOM MODEL - PXI DESIGN - RUN 13
EFFECT      * P 10 0
EFFECT      + I 12 0
FORMAT      (12F2.0)
PROCESS     7
GSTUDY      D. SET 3 - RANDOM MODEL - I:P DESIGN - RUN 14
REWIND      7
OPTIONS     RECORDS NONE
EFFECT      * P 10 0
EFFECT        I:P 12 0
FORMAT      (12F2.0)
PROCESS     7
GSTUDY      D. SET 3 - RANDOM MODEL - (P:C) X I DESIGN - RUN 15
REWIND      7
EFFECT      + C 2 0
EFFECT      * P:C 5 0
EFFECT        I 12 0
FORMAT      (12F2.0)
PROCESS     7
GSTUDY      D. SET 3 - RANDOM MODEL - P X (I:S) DESIGN - RUN 16
REWIND      7
EFFECT      * P 10 0
EFFECT      + S 3 0
EFFECT      + I:S 4 0
FORMAT      (12F2.0)
PROCESS     7
GSTUDY      D. SET 3 - S FIXED - P X (I:S) DESIGN - RUN 17
REWIND      7
EFFECT      * P 10 0
EFFECT      S 3 3
EFFECT      I:S 4 0
FORMAT      (12F2.0)
PROCESS     7
GSTUDY      D. SET 3 - RANDOM MOD. - (P:C)X(I:S) DESIGN - RUN 18
REWIND      7
EFFECT      + C 2 0
EFFECT      * P:C 5 0
EFFECT      + S 3 0
EFFECT      + I:S 4 0
FORMAT      (12F2.0)
PROCESS     7
FINISH
```

Using Alternate Logical Units for Control Card Input

GENOVA has two optional control cards, **READ** and **REVERT**, which allow the user to access control cards stored on one or more alternate logical units, intermingling them with the control cards found on logical unit 5 (the default input unit).

The READ card must have exactly one integer parameter in its data area (columns 13-80) specifying that control cards are to be read from the alternate logical unit defined by that integer until a REVERT card is encountered. The REVERT card instructs GENOVA to go back to the default logical input unit (five) for reading control cards.

Figure 4.8 shows a set of GENOVA control cards specifying several different studies utilizing the same data set. Instead of simply accessing the data via the logical unit specification on the PROCESS card and using REWIND cards to rewind the data set (as shown in Figure 4.7), in this example COMMENT cards describing the data set, the FORMAT card, the PROCESS card and the data set itself are stored on logical unit 9 (shown in Figure 4.9) and accessed for each study by issuing a READ card for logical unit 9.

Note that, in this example, data as well as control cards are read from the alternate logical input unit, number 9. A sample of the GENOVA control card listing for one of these studies is shown in Figure 4.10.

FIGURE 4.8

Sample Control Cards Using the READ and REWIND cards

```
Columns  1111111111222222222233333333334444444444555555555566666
         1234567890123456789012345678901234567890123456789012345678901234
```

```
GSTUDY      D. SET 3 - RANDOM MODEL - PXI DESIGN - RUN 13
EFFECT      * P 10 0
EFFECT      + I 12 0
READ        9
GSTUDY      D. SET 3 - RANDOM MODEL - I:P DESIGN - RUN 14
REWIND      9
OPTIONS     RECORDS NONE
EFFECT      * P 10 0
EFFECT        I:P 12 0
READ        9
GSTUDY      D. SET 3 - RANDOM MODEL - (P:C) X I DESIGN - RUN 15
REWIND      9
EFFECT      + C 2 0
EFFECT      * P:C 5 0
EFFECT        I 12 0
READ        9
GSTUDY      D. SET 3 - RANDOM MODEL - P X (I:S) DESIGN - RUN 16
REWIND      9
EFFECT      * P 10 0
EFFECT      + S 3 0
EFFECT      + I:S 4 0
READ        9
GSTUDY      D. SET 3 - S FIXED - P X (I:S) DESIGN - RUN 17
REWIND      9
EFFECT      * P 10 0
EFFECT      S 3 3
EFFECT      I:S 4 0
READ        9
GSTUDY      D. SET 3 - RANDOM MOD. - (P:C)X(I:S) DESIGN - RUN 18
REWIND      9
EFFECT      + C 2 0
EFFECT      * P:C 5 0
EFFECT      + S 3 0
EFFECT      + I:S 4 0
READ        9
FINISH
```

FIGURE 4.9

Sample Alternate Input File Using the REVERT Card

```
Columns  111111111122222222223333333333444444444455555555556666666
1234567890123456789012345678901234567890123456789012345678901234
```

```
COMMENT      COLUMNS  111111111122222
COMMENT      123456789012345678901234
COMMENT
COMMENT       1 0 1 0 0 0 0 0 0 0 0 0
COMMENT       1 1 1 0 0 1 0 0 0 0 0 0
COMMENT       1 1 1 1 1 0 0 0 0 0 0 0
COMMENT       1 1 0 1 1 0 0 1 0 0 0 0
COMMENT       1 1 1 1 1 0 1 0 0 0 0 0
COMMENT       1 1 1 0 1 1 1 0 0 0 0 0
COMMENT       1 1 1 1 1 1 1 0 0 0 0 0
COMMENT       1 1 1 1 0 1 1 1 1 1 0 0
COMMENT       1 1 1 1 1 1 1 1 1 1 1 0
COMMENT       1 1 1 1 1 1 1 1 1 1 1 1
COMMENT
COMMENT      # RECORDS = 10
COMMENT      VALUES PER RECORD = 12
COMMENT
FORMAT       (12F2.0)
PROCESS
 1 0 1 0 0 0 0 0 0 0 0 0
 1 1 1 0 0 1 0 0 0 0 0 0
 1 1 1 1 1 0 0 0 0 0 0 0
 1 1 0 1 1 0 0 1 0 0 0 0
 1 1 1 1 1 0 1 0 0 0 0 0
 1 1 1 0 1 1 1 0 0 0 0 0
 1 1 1 1 1 1 1 0 0 0 0 0
 1 1 1 1 0 1 1 1 1 1 0 0
 1 1 1 1 1 1 1 1 1 1 1 0
 1 1 1 1 1 1 1 1 1 1 1 1
REVERT
```

CONTROL CARD INPUT LISTING

```
COLUMN    1111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789
GSTUDY       D. SET 3 - RANDOM MODEL - PXI DESIGN - RUN 13
EFFECT       * P 10 0
EFFECT       + I 12 0
READ         9
COMMENT      COLUMNS  111111111122222
COMMENT      123456789012345678901234
COMMENT
COMMENT       1 0 1 0 0 0 0 0 0 0 0 0
COMMENT       1 1 1 0 0 1 0 0 0 0 0 0
COMMENT       1 1 1 1 1 0 0 0 0 0 0 0
COMMENT       1 1 0 1 1 0 0 1 0 0 0 0
COMMENT       1 1 1 1 1 0 1 0 0 0 0 0
COMMENT       1 1 1 0 1 1 1 0 0 0 0 0
COMMENT       1 1 1 1 1 1 1 0 0 0 0 0
COMMENT       1 1 1 1 0 1 1 1 1 1 0 0
COMMENT       1 1 1 1 1 1 1 1 1 1 1 0
COMMENT       1 1 1 1 1 1 1 1 1 1 1 1
COMMENT
COMMENT      # RECORDS = 10
COMMENT      VALUES PER RECORD = 12
COMMENT
FORMAT       (12F2.0)
PROCESS
```

FIGURE 4.10

SAMPLE CONTROL CARD LISTING FOR FIGURES 4.8 AND 4.9

Computer-Related Technical Considerations

GENOVA is written in standard FORTRAN IV in a highly modularized fashion to facilitate its implementation on almost any computer with a FORTRAN IV compiler. GENOVA was originally developed and implemented on a Control Data CYBER 175, but has also been installed on an IBM 370 and a PRIME 750. (Note: GENOVA has also been compiled and executed under FORTRAN 77 compilors with no modification.)

GENOVA Modules

GENOVA consists of 1 mainline program, 85 subroutines, 5 logical functions, three double precision functions and two integer functions. These ninety-six modules consist of approximately 16,200 80-column card images.

Implementation Considerations

There are two subroutines, SYSINP and SYSPAG, that may need to be modified to implement GENOVA on another computer system. SYSINP uses the standard 'END=' parameter on the READ statement. On other systems which do not support the 'END=' parameter on a READ, the READ statement will have to be replaced.

The SYSPAG subroutine prints out the first line on each output page that GENOVA produces, including an optional date and time-stamp. Since access to system time and date information vary dramatically from system to system, part of SYSPAG will need to be modified to format and print this information as part of each output page headline.

The second part of SYSPAG, starting at statement 100 is executed only once, the first time that SYSPAG is entered. Starting at statement 100, system-dependent code to get the date and time information should be entered, followed by statement 200 which initializes the page number variable to 1 and goes back to the first part of the routine. Format 91 and the WRITE statement at 20 may have to be changed to handle the date-time information from a particular system. In addition, any variable needed to hold the date-time information for printing can be stored into the SYSDTE common block. (The SYSDTE common block is referenced <u>only</u> in the SYSPAG routine.)

Obviously, the heading line can be tailored to suit your installations needs, ignoring the date-time output entirely or adding the installation name, etc. In any case, this should be the only routine that has to be modified for the majority of installations.

Since the subroutines and functions are in alphabetical order, finding the location of this required change should not be too difficult.

Data Storage Restrictions

GENOVA assumes, and is dependent upon the fact, that integer and single precision real variables occupy the same amount of space on the host computer. GENOVA also assumes that double precision real variables (which are used extensively in GENOVA) take twice the space of integer or single precision real variables.

An attempt to conserve space by using INTEGER*2 or some equivalent control statements will have unpredictable results.

File Assignments in GENOVA

Table 4.1 shows the default logical file unit assignments made by GENOVA for input, output and work file.

TABLE 4.1

Default GENOVA Logical Unit Assignments

FILE	LOGICAL RECORD LENGTH	LOGICAL UNIT NUMBER	RECORD TYPE
INPUT	80 CHARACTERS	5	FORMATTED
OUTPUT	133 CHARACTERS	6	FORMATTED
WORK FILE	80 CHARACTERS	14	UNFORMATTED

The internal assignments for these logical units are made in subroutine INITGN and must be modified if different default logical unit number assignments are desired.

System Control Cards for GENOVA

Figure 4.11 provides sets of CDC CYBER CCL control cards for two GENOVA jobs. The first job does the following: (a) compiles GENOVA generating a load module called XGENOVA; (b) executes this load module using the control cards and input data matrix for simple run No. 1 in Figure 2.1 and (c) saves GENOVA and XGENOVA on indirect access permanent files. The second example uses the load module XGENOVA (generated by the first job) and executes the example shown in Figures 4.8 and 4.9.

FIGURE 4.11

Illustrative CDC CCL Set-ups

CCL FOR SIMPLE RUN NUMBER 1

```
COLUMNS  1111111111222222222233333333334444444444555555555556
1234567890123456789012345678901234567890123456789012345678901234567890

'JOB CARD'
'USER CARD'
COPYCR,INPUT,GENOVA.
REWIND,GENOVA.
FTN,I=GENOVA,B=XGENOVA.
SAVE,GENOVA,XGENOVA.
XGENOVA.
DAYFILE.
EXIT.
7/8/9
    (GENOVA SOURCE PROGRAM)
7/8/9
    (CONTROL CARDS, INCLUDING DATA, FOR SIMPLE RUN NO. 1)
6/7/8/9
```

CCL FOR EXAMPLE SHOWN IN FIGURES 4.8 AND 4.9

```
COLUMNS  1111111111222222222233333333334444444444555555555556
1234567890123456789012345678901234567890123456789012345678901234567890

'JOB CARD'
'USER CARD'
COPYCR,INPUT,TAPE9.
REWIND,TAPE9.
GET,XGENOVA.
XGENOVA.
DAYFILE.
EXIT.
7/8/9
    (CONTROL CARDS AND DATA SHOWN IN FIGURE 4.9)
7/8/9
    (CONTROL CARDS SHOWN IN FIGURE 4.8)
6/7/8/9
```

FIGURE 4.12

Illustrative IBM JCL Set-ups

JCL FOR SIMPLE RUN NUMBER 1

```
COLUMNS  1111111111222222222233333333334444444444555555555566
1234567890123456789012345678901234567890123456789012345678901 2
'JOB CARD'
//ST1 EXEC FORTGCLG,PARM.FORT='MAP',
// PARM.LKED='SIZE=(240K,200K),MAP,XREF',
// REGION.LKED=450K,REGION.GO=300K
//FORT.SYSIN DD UNIT=3350,DISP=OLD,
// DSN=WYL.CCO.BOB.GENOV2,VOL=SER=WYLB05
//LKED.SYSLMOD DD UNIT=3350,DSN=USER.I0121585.RBLIB(XGENOV2),
// DISP=(,CATLG),SPACE=(CYL,(90,2,2))
//LKED.SYSPRINT DD SYSOUT=A
//GO.FT05F001 DD *
   (CONTROL CARDS INCLUDING INPUT DATA FOR SIMPLE RUN # 1)
/*
//GO.FT06F001 DD SYSOUT=A
//FT14F001 DD UNIT=3350,DSN=&&TEMP,SPACE=(TRK,(10,9)),
//  DCB=(RECFM=VS,BLKSIZE=80),DISP=(NEW,PASS)
//
```

JCL FOR EXAMPLE SHOWN IN FIGURE 4.6

```
COLUMNS  1111111111222222222233333333334444444444555555555566
1234567890123456789012345678901234567890123456789012345678901 2
'JOB CARD'
//JOBLIB  DD DSN=USER.I0121585.RBLIB2,UNIT=3350,DISP=SHR
//ST1  EXEC    PGM=IEBGENER
//SYSPRINT DD  SYSOUT=A
//SYSUT1  DD   *,DCB=BLKSIZE=80
    (INPUT DATA MATRIX FOR EXAMPLE SHOWN IN FIGURE 4.6)
/*
//SYSUT2  DD   DSN=&&RBTEM1,UNIT=SYSDA,DISP=(NEW,PASS),
//   DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),SPACE=(CYL,(1,1))
//SYSIN DD *
 GENERATE MAXFLDS=1
 RECORD FIELD=(80,1,1)
/*
//ST2  EXEC    PGM=XGENOV2,REGION=250K
//FT06F001 DD SYSOUT=A
//FT07F001 DD DSN=&&RBTEM1,UNIT=SYSDA,DISP=(OLD,DELETE)
//FT14F001 DD DSN=&&RBTEM2,UNIT=SYSDA,DISP=(NEW,PASS),
//   DCB=(RECFM=VS,BLKSIZE=80),SPACE=(TRK,(10,9))
//FT05F001 DD *
    (CONTROL CARDS FOR EXAMPLE SHOWN IN FIGURE 4.6)
/*
//
```

Figure 4.12 provides sets of IBM JCL control cards for two GENOVA jobs. The first job does the following: (a) compiles and link edits GENOVA storing the load module, XGENOVA, on disk as an element of a partitioned data set, RBLIB; and (b) executes XGENOVA using the control cards and input data matrix for Simple Run Number 1 from Figure 2.1 The second job does the following: (a) uses IEBGENER to store the input data matrix for the example in Figure 4.6 on a temporary disk data set named &&RBTEM1; and (b) executes the load module XGENOVA (generated in the first job) using the control cards from Figure 4.6 (plus a FINISH card which is not) shown) as input.

Note that the both jobs contain a //FT14 card because NAME control cards may be used in any GENOVA job, and they require the use of logical unit #14. Since records written on, or read from, this work file do not employ format control, RECFM=VS for //FT14. Even if NAME control cards are not present in a particular job, the //FT14 JCL statement should be present.

Execution Times

A more complete discussion of execution speeds and comparisons with BMD08V, BMDP8V, and SAS is found in Brennan, 1983, pp. 105-107.

In summary, GENOVA is normally 5 to 7 times faster than SAS and requires less central memory than SAS, particularly on larger data sets.

A reasonable estimate for GENOVA is 3,500 data points (observations) per second on an IBM 370/168.

In general, GENOVA appears to be able to analyze extensive data sets in a very reasonable amount of computer time, and the complexity of the design has relatively little effect of the amount of time required relative to the size of the data set.

Core Requirements

The current version of GENOVA requires 124K words of central memory to execute on a CDC CYBER 175 and 250K bytes of central memory on an IBM 370/168. Moreover, the current version includes common buffer areas sufficient to handle almost any study that would be presented to GENOVA.

APPENDIX A

FULL DESCRIPTION OF CONTROL CARDS AND FIELDS

Each control card for the GENOVA program begins with a set of characters, called a control card identifier, left-justified in columns 1-12. The first four of these characters must be provided exactly as indicated. Otherwise, the program will print an error message and may terminate execution depending upon the control card that is in error.

Since only the first four columns are checked for a control card identifier, the remaining eight columns are ignored by GENOVA except for continuation cards (see discussion below). The control card identifiers are listed below:

COMMENT
DCUT
DEFFECT
DSTUDY
EFFECT
ENDCOMP
ENDDSTUDY
ENDMEAN
FINISH
FORMAT
GCOMPONENTS
GMEANSQUARES
GSTUDY
MEANSQUARE
NAME
OPTIONS
OUTPUT
PROCESS
READ
REWIND
REVERT
STUDY
SUBHEADING
VCOMPONENT

Note that the control card identifier for each of the GENOVA control cards can occupy up to twelve columns, but only the first four must be correctly spelled.

In general, an execution of GENOVA is a series of one or more job steps. A GENOVA job step consists of a set of control cards, initiated by a 'GSTUDY' (or 'STUDY'), a 'GMEANSQUARES' or a 'GCOMPONENTS' card, and terminated by a 'PROCESS', an 'ENDMEAN' or an 'ENDCOMP' card, respectively. Optionally, any of these sets of control cards may be followed by one or more sets of D study control cards starting with a 'DSTUDY' card and terminated

with an 'ENDDSTUDY' control card. A GENOVA execution is terminated by a 'FINISH' control card which must always be present.

Each of the control cards will be described in detail below. Except for the control card identifier in columns 1-12, all other information on control cards is free-format (i.e. may appear anywhere in columns 13-80). Some control cards may be more than one card long with the exceptions noted below.

For those control cards which have optional variables, they will be denoted as optional by being enclosed in brackets. The notation **"..."** will indicate that the previous variable may occur several times on the particular control card.

The variables to be provided by the user on each control card are described below. For each variable, information will be provided on (a) the name of the variable, (b) the format type of the variable and (c) a description of the variable and its uses.

All variables on GENOVA control cards are distinguished from one another by a separator field. A separator field consists of 1 or more columns containing only **blanks** and/or **commas.**

For each variable whose format is identified as **I**, the user-specified value of the variable should be an integer (i.e., a whole number <u>without</u> a decimal point).

When a variable requires a character or set of characters as a value, the format type is specified as **A** or **C** for character string. Since GENOVA uses blanks and commas for delimiters, there are two ways to provide character string data to the program. If the character data being provided have no internal or imbedded blanks or commas, then the data can simply be entered on the control card (e.g. **A** or **P:C**). If, however, there are either commas or blanks imbedded in the character data the user is specifying, then the entire string must be included in quotation marks (e.g. **"TEST NUMBER"**) and will be specified as **C** format.

For each variable whose format is identified as **F**, the user-specified value is expected to be a number <u>with a decimal point in the appropriate position</u>, even if the value is a whole number.

<u>Continuation Cards</u>

A GENOVA continuation card is any control card which is blank in columns 1-12. For those control cards which can have continuations (with the exception of the FORMAT control card) the number of continuation cards is unlimited. See discussion of each individual control card for restrictions on the use of continuations.

COMMENT Card

The COMMENT card is a mechanism to allow the user to place comments or notes into the GENOVA output about the study or the data that do not fit on any of the other control cards.

Columns: 1-7 Variable: 'COMMENT' Format: A

The card identifier 'COMMENT' should appear in columns 1-7. Note that columns 1-4 must contain 'COMM'.

Columns: 13-80 Variable: TEXT Format: A

The TEXT in columns 13-80 of a comment card does not have to be enclosed in quotes and can contain any characters available on a keypunch. TEXT is only printed out by GENOVA and is not used in any other manner.

COMMENT cards may appear anywhere in the GENOVA input deck, but each comment is limited to one card and can not be continued onto a second card.

To continue a comment onto additional cards, the user must start each additional card with the card identifier 'COMMENT'.

DCUT Card

The DCUT card is an optional control card which may be present whenever a DSTUDY set of control cards is being processed, and may appear anywhere between a DSTUDY and an ENDDSTUDY control card. Whenever a DCUT control card is encountered during a DSTUDY run, GENOVA will provide D study optional output involving cutting scores. If no DCUT control card occurs in a DSTUDY set of control cards, no cutting score output will be produced.

Columns: 1-4 Variable: 'DCUT' Format: A

The card identifier 'DCUT' must appear in columns 1-4.

There are two types of basic data that can appear in columns 13-80 of a DCUT card and its continuations, depending upon how the user wants to specify the cutting scores to be used in this DSTUDY processing run:

Option 1: A 'standard set of cutting scores' = 0.0, 0.1, 0.2, ..., 0.8, 0.9, 1.0 (eleven values).
Data in columns 13-80: Blank or keyword 'STANDARD'

Option 2: A vector of user-defined cutting scores in F format (from one to thirty values).

A maximum of 30 user-specified cutting scores will be anticipated but as few as one may be specified. It is generally best (although not absolutely necessary) to order the cutting scores from lowest to highest. Each of the cutting scores provided must include a decimal point since the required format is type F.

Each DCUT control card may optionally have a grand mean (GMEAN) specified at the end of all other data fields on the DCUT card by using a '/' followed by a blank or comma and then the grand mean value in type F format. This option is necessary only when a DSTUDY run follows either a GCOMPONENTS or a GMEANSQUARES processing run since these runs do not deal with raw data and therefore do not calculate a grand mean. If this option is employed when a DSTUDY run follows a GSTUDY (or STUDY) run, then GMEAN is used rather that the computed mean from the GSTUDY. A grand mean is necessary to provide cutting score output.

Format #1: Standard cutting scores with optional grand mean.

DCUT STANDARD [/ GMEAN]
or
DCUT [/ GMEAN]

Format #2: User specified cutting scores with optional grand mean.

DCUT DCUT1 [DCUT2] ... [DCUTn] [/ GMEAN]

Samples for Format #2:

```
DCUT        0.70
DCUT        0.25 0.50 0.75 1.  / 0.6125
```

Continuation Cards: A DCUT card may have as many continuation cards as the user desires.

DEFFECT Card

The DEFFECT control card provides the detailed input values required on a DSTUDY run of GENOVA. The DEFFECT card will supply the facets, their sampling and universe sizes, and the object of measurement for the D study processing.

Columns: 1-7 Variable: 'DEFFECT' Format: A

The card identifier 'DEFFECT' should appear in columns 1-7. Note that columns 1-4 must contain 'DEFF'.

The general format of the data which can appear in columns 13-80 of a DEFFECT card and its continuations is the following:

[$] DFACET [ISAMPD (1 or more)] [/ IUNIVD]

Columns: variable Variable: IDOLL Format: A

IDOLL is the literal character '$' that indicates that this facet is the object of measurement for the D study. IDOLL must appear on exactly one of the DEFFECT cards for a D study run (initiated by a DSTUDY card and terminated by an ENDDSTUDY card) and, when it does appear, it must immediately precede the letter that denotes the object of measurement facet. Note that the object of measurement must be a non-nested facet; i.e., a facet designated without any colons.

Columns: variable Variable: DFACET Format: A

DFACET is a one-to-eleven character string describing a facet for the D study. DFACET can only contain letters (A-Z) and colons (':') to describe the facet (see discussion of notation in the body of this manual). The colon is used to denote nesting. DFACET must appear on every DEFFECT card as either the second (following IDOLL) or the first data field in the data area of the card.

Columns: variable Variable: ISAMPD Format: I
Restrictions: Up to 30 values
Default: Use sample size from the preceding G study analysis.

ISAMPD is one or more user-specified integer values indicating the sample size(s) to be used for D study processing. ISAMPD values (if present) always follow immediately after DFACET as the next data field(s) on each DEFFECT control card.

If no ISAMPD values are specified on a given DEFFECT card, the sample size (number of levels) from the preceding G study analysis for the same main effect character is used.

If more than one ISAMPD value is provided on any DEFFECT card, multiple D study analyses will be performed, one with each specified ISAMPD value (see discussion below).

Columns: variable Variable: KSLASH Format: A

KSLASH is the literal character '/' that indicates that the next data field encountered will be a D study universe size. KSLASH is optional, but must always appear when a IUNIVD value is to be specified. KSLASH and IUNIVD must appear as the last two values on a DEFFECT card.

Columns: variable Variable: IUNIVD Format: I
Default: Use universe size from preceding G study analysis.
Note: Zero ==> Infinity

IUNIVD is an optional user-specified integer value used to indicate the D study universe size for the facet specified on this DEFFECT card. Zero implies an infinite universe for this facet. The default, if IUNIVD is not specified, is the universe size from the preceding G study processing.

Note: The maximum number of DEFFECT cards for a single set of DSTUDY control cards is SIX, since that is the maximum number of main effects (and the maximum number of facets) that GENOVA allows.

RESTRICTION: If IUNIVD is not infinite then every ISAMPD value must be <= IUNIVD.

CONTINUATION Cards: A DEFFECT card can have as many continuation cards as the user desires.

EXPLANATION: Sample Size Interactions.

As noted above, more than one sample size (ISAMPD: up to 30) can be specified on each DEFFECT card. A separate set of D study results will be provided for each sample size specified. The number of D study results produced from a set of DSTUDY control cards will equal the largest number of ISAMPD values specified on a DEFFECT card.

It is not necessary to have the same number of ISAMPD values on each DEFFECT card since GENOVA will simply extend the last sample size specified for a facet as many times as necessary (up to thirty total). Consider the DEFFECT cards below:

```
DEFFECT     $ P 10 10 20
DEFFECT     R 3 / 3
DEFFECT     I:R 1 2 3 4 5
```

These DEFFECT cards will result in five separate D study analyses and would have the same effect as the following DEFFECT control cards:

```
DEFFECT     $ P 10 10 20 20 20
DEFFECT     R 3 3 3 3 3 / 3
DEFFECT     I:R 1 2 3 4 5
```

For the first set of DEFFECT cards, the largest number of sample sizes (five) occurs on the 'I:R' card. The last sample size of the 'P' card (20) is logically extended two more times and the single sample size (3) on the 'R' card is logically extended four more times when processing starts for the D study. Therefore the first set of DEFFECT control cards would have exactly the same effect as the second set of control cards.

DSTUDY Card

The DSTUDY card signals the beginning of a series of control cards which will specify a D study to be performed based on the results of the last G study processing. The specific data which changes for the D study may be the design, the sample and universe sizes, and the specification of the object of measurement for the D study. The last control card in this series is the ENDDSTUDY card. The DSTUDY control card is similar in function to a GSTUDY card except that it initiates a D study rather than a G study processing.

Columns: 1-6 Variable: 'DSTUDY' Format: A

The card identifier 'DSTUDY' should appear in columns 1-6. Note that columns 1-4 must contain 'DSTU'.

Columns: 13-8Ø Variable: KTITLE Format: A

KTITLE is a user-defined alphanumeric heading which will appear on each output page of the D study results. Like the GSTUDY or STUDY cards, the DSTUDY control card cannot have any continuation cards and KTITLE should not be enclosed in quotes.

KTITLE will appear as the primary heading on each output page of the D study results and, if it is blank, the heading will also be blank.

Note: The SUBHEADING card can be used in conjunction with the DSTUDY card to provide sub-headings as well as primary headings for the output (see description of the SUBHEADINGS card).

EFFECT Card

The EFFECT control card provides the detailed input values required on a STUDY or GSTUDY run of GENOVA. The EFFECT cards will specify the facets, the sampling and universe sizes for each facet, the record or "starred" facet and whether or not cell means are to be printed. The order of the EFFECT cards will also indicate the order of the data to be read from the data file.

Columns: 1-6 Variable: 'EFFECT' Format: A

The card identifier 'EFFECT' should appear in columns 1-6. Note that columns 1-4 must contain 'EFFE'.

The general format of the data which can appear in columns 13-80 on an EFFECT card and its continuations is the following:

[* or +] MFACET NUMLEV [NPOPUL]

Columns: variable Variable: NSTAR Format: A

NSTAR is the literal character '*' that indicates that this is the "starred" effect for input purposes (see discussion in the body of this manual). NSTAR can appear on exactly one of the EFFECT cards for an individual study initiated by a GSTUDY or STUDY card and, when it does appear, it must immediately precede the character string that denotes the starred facet.

Columns: variable Variable: NPLUS Format: A

NPLUS is the literal character '+' that indicates that cell mean scores are to printed out for all levels of the effect. If two or more effects are preceded by '+', then the means for all combinations of levels of these effects will be printed also.

NPLUS can not appear in conjunction with NSTAR on the same EFFECT card, and when NPLUS does appear, it must immediately precede the facet to which it refers.

Columns: variable Variable: MFACET Format: A

MFACET is a one-to-eleven character string describing a facet for the study. MFACET can only contain letters (A-Z) and colons (':') to describe a facet (see discussion of notation in the body of this manual). The colon is used to indicate nesting. MFACET must appear on every EFFECT card as either the second (following NSTAR or NPLUS) or the first data field on the card.

Columns: variable Variable: NUMLEV Format: I
Restrictions: NUMLEV >= 2

NUMLEV is a user-specified integer value indicating the number of levels of data for this facet that will appear in the input data (see discussion of levels in the body of the manual). NUMLEV always follows immediately after MFACET as the next data field on each EFFECT control card.

Columns: variable Variable: NPOPUL Format: I

Default: Zero ==> Infinity

NPOPUL is an optional user-specified integer value used to indicate the population or universe size for the facet specified on this EFFECT card. Zero is the default value which implies an infinite universe for this facet. NPOPUL is used primarily to calculate the variance components and expected mean square equations for the specified model.

If no values are specified for NPOPUL on any of the EFFECT cards, then the model is assumed to be a totally random model. To specify a fixed effect, NPOPUL must be made equal to NUMLEV.

Note: The maximum number of EFFECT cards for a single study (initiated by a GSTUDY or STUDY card) is SIX, since that is the maximum number of main effects (and the maximum number of facets) that GENOVA can handle.

RESTRICTION: The order of facets on EFFECT cards is important and they must appear in the same order as the facets appear in the input data, with the first facet specified corresponding to the facet whose subscripts or levels are varying least rapidly.

RESTRICTION: If NPOPUL is not zero (==> infinite), then NUMLEV must be <= NPOPUL.

CONTINUATION CARDS: An EFFECT card can have as many continuation cards as the user desires.

ENDCOMP Card

The ENDCOMP control card is the final card in a GCOMPONENTS run and indicates that all input is complete and that processing should commence.

Columns: 1-7 Variable: 'ENDCOMP' Format: A

The card identifier 'ENDCOMP' should appear in columns 1-7. Note that columns 1-4 must contain 'ENDC'.

The general format of the data which can appear in columns 13-80 on an ENDCOMP card is the following:

['DEFAULT'] [/ GMEAN]

The literal 'DEFAULT' (entered without apostrophes), when present on an ENDCOMP card specifies that a default D-study is to be performed after the GCOMPONENTS processing is completed.

GMEAN is an optional real value specifying the grand mean of the G study represented by this GCOMPONENTS run of GENOVA. The GMEAN value is necessary only when a D study set of control cards is to follow and cutting score output is desired.

If GMEAN is specified, it must follow a literal slash '/'.

The ENDCOMP card can have no continuation cards.

ENDDSTUDY Card

The ENDDSTUDY control card is the final card in a DSTUDY run and indicates that all input is complete and that processing should commence.

Columns: 1-9 Variable: 'ENDDSTUDY' Format: A

The card identifier 'ENDDSTUDY' should appear in columns 1-9. Note that columns 1-4 must contain 'ENDD'.

The general format of the data which can appear in columns 13-80 on an ENDDSTUDY card is the following:

[GMEAN]

Columns: variable Variable: GMEAN Format: F

GMEAN is an optional real value specifying the grand mean of the previous G study procesing. GMEAN is required only when a DCUT card has been processed and the previous G study processing was either a GMEANSQUARES run or a GCOMPONENTS run.

CONTINUATION Cards: Even though they should not be needed, the user may use as many continuations of the ENDDSTUDY card as desired.

ENDMEAN Card

The ENDMEAN control card is the final card in a GMEANSQUARES run and indicates that all input is complete and that processing should commence.

Columns: 1-7 Variable: 'ENDMEAN' Format: A

The card identifier 'ENDMEAN' should appear in columns 1-7. Note that columns 1-4 must contain 'ENDM'.

The general format of the data which can appear in columns 13-80 on an ENDMEAN card is the following:

['DEFAULT'] [/ GMEAN]

The literal 'DEFAULT' (entered without apostrophes), when present on an ENDMEAN card specifies that a default D-study is to be performed after the GMEANSQUARES processing is completed.

GMEAN is an optional real value specifying the grand mean of the G study represented by this GMEANSQUARES run of GENOVA. The GMEAN value is necessary only when a D study set of control cards is to follow and cutting score output is desired.

If GMEAN is specified, it must follow a literal slash '/'.

The literal 'DEFAULT' (entered without apostrophes), when present on an ENDMEAN card specifies that a default D-study is to be performed after the GMEANSQUARES processing is completed.

The ENDMEAN card can have no continuation cards.

FINISH Card

The FINISH card signals the end of all GENOVA processing.

Columns: 1-6 Variable: 'FINISH' Format: A

The card identifier 'FINISH' should appear in columns 1-6. Note that columns 1-4 must contain 'FINI'.

FORMAT Card

The FORMAT control card is used to specify the FORTRAN object-time format for reading in the data on a GSTUDY or GSTUDY run of GENOVA.

Columns: 1-6 Variable: 'FORMAT' Format: A

The card identifier 'FORMAT' should appear in columns 1-6. Note that columns 1-4 must contain 'FORM'.

Columns: 13-80 Variable: KFORM Format: A

KFORM is a FORTRAN object-time format which will be used to read in the data for a STUDY or GSTUDY run. Up to **two** continuation cards may be used for the object-time format (204 characters). The format must be enclosed within parentheses.

GCOMPONENTS Card

The GCOMPONENTS card signals the start of a series of control cards which will specify to GENOVA the variance components for a previously completed study. This data can then be used to calculate standard errors and produce the variance-covariance matrix. The last control card in this series is an ENDCOMP card.

Columns: 1-11 Variable: 'GCOMPONENTS' Format: A

The card identifier 'GCOMPONENTS' should appear in columns 1-11. Note that columns 1-4 must contain 'GCOM'.

Columns: 13-80 Variable: KTITLE Format: A

KTITLE is a user-defined alphanumeric heading which will appear on each output page of the results generated from the variance components data. The GCOMPONENTS card cannot have any continuations and KTITLE should not be enclosed in quotes.

KTITLE will appear as the primary heading on each output page of the results and, if it is blank, the heading will also be blank.

Note: The SUBHEADING card can be used in conjunction with the GCOMPONENTS card to provide sub-headings in addition to the primary headings for the study results (see description of the SUBHEADING card).

GMEANSQUARES Card

The GMEANSQUARES card signals the start of a series of control cards which will specify to GENOVA the mean squares from a previously completed study. This data can then be used to produce all the standard GENOVA outputs except for input record listings and cell means. The last control card in this series is an ENDMEAN card.

Columns: 1-12 Variable: 'GMEANSQUARES' Format: A

The card identifier 'GMEANSQUARES' should appear in columns 1-12. Note that columns 1-4 must contain 'GMEA'.

Columns: 13-80 Variable: KTITLE Format: A

KTITLE is a user-defined alphanumeric heading which will appear on each output page of the results generated from the mean squares data. Like the GCOMPONENTS card, the GMEANSQUARES card cannot have any continuations and KTITLE should not be enclosed in quotes.

KTITLE will appear as the primary heading on each output page of the results and, if it is blank, the heading will also be blank.

Note: The SUBHEADING card can be used in conjunction with the GMEANSQUARES card to provide subheadings in addition to the primary headings for the results of the mean squares input analysis (see description of the SUBHEADING card).

GSTUDY Card

A GSTUDY card signals the beginning of a series of control cards which will specify a study to be performed from raw data. The last control card in this series is a PROCESS card. The GSTUDY control card is identical in function to a STUDY card and they can be used interchangeably.

Columns: 1-6 Variable: 'GSTUDY' Format: A

The card identifier 'GSTUDY' should appear in columns 1-6. Note that columns 1-4 must contain 'GSTU'.

Columns: 13-80 Variable: KTITLE Format: A

KTITLE is a user-defined alphanumeric heading which will appear on each output page of the study results. Like the GMEANSQUARES and GCOMPONENTS cards, the GSTUDY card cannot have any continuation cards and KTITLE should not be enclosed in quotes.

KTITLE will appear as the primary heading on each output page of the results and, if it is blank, the heading will also be blank.

Note: The SUBHEADING card can be used in conjunction with the GSTUDY card to provide sub-headings as well as primary headings for the output (see description of the SUBHEADING card).

MEANSQUARE Card

The MEANSQUARE card provides the detailed input values required on a GMEANSQUARES run of GENOVA. The MEANSQUARE cards specify the mean squares for all main and interaction effects, as well as the sample and universe (or population) sizes for the facet associated with the primary index in each main effect.

Columns: 1-10 Variable: 'MEANSQUARE' Format: A

The card identifier 'MEANSQUARE' should appear in columns 1-10. Note that columns 1-4 must contain 'MEAN'.

The two general formats for the data area (columns 13-80) of the MEANSQUARE card and its continuations are as follows:

Format 1: **MFACET XMSQR NSAMP [NUNIV]**

Format 2: **MEFFCT XMSQR**

Format 1 of the MEANSQUARE card is used for the main effects of the design (maximum of **6**) and must come first. Format 2 is used for all of the interaction effects for the design.

Columns: variable Variable: MFACET Format: A

MFACET is a one-to-eleven character character-string describing a main effect for this study. MFACET can only contain letters (A-Z) and colons (':') to describe a main effect (see discussion of notation in the body of this manual). The colon is used to indicate nesting. MFACET must appear as the first data field of every format 1 MEANSQUARE card.

Columns: variable Variable: MEFFCT Format: A

MEFFCT is formed exactly like MFACET, but it will represent an interaction effect, rather than a main effect. MEFFCT must appear first on every format 2 MEANSQUARE card.

Columns: variable Variable: XMSQR Format: F

XMSQR will be a user-supplied real number specifying the value of the mean square associated with the respective main effect (MFACET on format 1) or interaction effect (MEFFCT on format 2). A XMSQR value must appear as the second data field on every MEANSQUARE card.

Columns: variable Variable: NSAMP Format: I

NSAMP is a user-supplied integer value indicating the number of levels of data which occurred for this facet in the study which gave rise to these mean squares. NSAMP always follows immediately after MFACET as the next data field on each format 1 MEANSQUARE card.

Columns: variable Variable: NUNIV Format: I
Default: Zero ==> Infinity

NUNIV is an optional user-specified integer value used to indicate the population or universe size for the facet specified on this MEANSQUARE card in the study which produced these mean squares. Zero is the default value which implies an infinite universe for this facet.

Note: It is important to have accurate values for NSAMP and appropriate values for NUNIV to ensure accurate and meaningfull estimates of variance components and their standard errors. Furthermore, there must be a MEANSQUARE card for each effect in the full model, and each card must contain a mean squares value.

Order of Input: The order of the MEANSQUARE cards is relatively simple, but very important: All format 1 cards for the main effects must precede the format 2 cards for the interaction effects. Any other ordering will result in an error and GMEANSQUARES processing will be terminated.

In addition, the format 1 cards must be ordered such that a nested facet is specified after the facets within which it is nested. For example, the MEANSQUARE card for **T** must precede the MEANSQUARE card for **I:T** in a **P x (I:T)** design and the MEANSQUARE cards for **A**, B and **C** must precede the MEANSQUARE card for **S:ABC** in an **S:(ABC)** design.

Suppose that the design for a particular study was **P x (I:T)**, or p crossed with i nested within t. There would have to be three format 1 MEANSQUARE cards (for P, T, and I:T) for the three main effects with I:T following T, followed by two format 2 MEANSQUARE cards in either order for the two interaction effects (PT and PI:T).

RESTRICTION: NSAMP >= 2 and if NUNIV is not zero, NSAMP <= NUNIV.

RESTRICTION: A maximum of six format 1 MEANSQUARE cards can appear in a single GMEANSQUARES run of GENOVA. It should also be noted that format 2 MEANSQUARE cards must be specified for each possible interaction effect, or GENOVA cannot perform the GMEANSQUARES processing.

Continuation Cards: A MEANSQUARE card may have as many continuation cards as the user desires.

NAME Card

The NAME card is an optional control card for a GSTUDY or STUDY run to allow the user to specify names to be associated with one or more of the main effect characters. For example, if the study design is 'P x I' (P crossed with I), the user could use the NAME card to specify that 'P' stands for 'PERSONS' and that 'I' represents 'ITEMS'.

Columns: 1-4 Variable: 'NAME' Format: A

The card identifier 'NAME' must appear in columns 1-4.

The format for the data area of the NAME card data area (columns 13-80) is as follows:

MCHAR MNAME

Columns: variable Variable: MCHAR Format: A

MCHAR must have a value of a single letter which must match one of the letters entered on a previous EFFECT card.

Columns: variable Variable: MNAME Format: C

MNAME is a user-specified character-string variable enclosed in double quotes which should contain the descriptive name for the main effect character 'MCHAR', e.g. **"PERSON"** or **"CLASS SECTION"**.

The NAME card can have no continuation cards and each individual NAME card must come after the EFFECT card which specifies the particular facet that the NAME card is referencing.

OPTIONS Card

The OPTIONS control card is used to logically set or reset several GENOVA output options.

Columns: 1-7 Variable: 'OPTIONS' Format: A

The card identifier 'OPTIONS' should appear in columns 1-7. Note that columns 1-4 must contain 'OPTI'.

The general format of the data area (columns 13-8Ø) of the OPTIONS card is as follows:

[RECORDS [numrec, ALL, or NONE]] [NEGATIVE]
[CORRELATION] [ECOLOGY] [EMS] [ALGORITHM]
[DTABLE] [RESET]

The 'RECORDS' parameter, followed by a specification parameter, on an OPTIONS card is used to control the number of input records that are to be printed out, with record means, on a GSTUDY or STUDY GENOVA run.

'RECORDS ALL' will cause all input records to be printed out with their means.

'RECORDS NONE' will inhibit the printing of input records.

'RECORDS numrec', where numrec is a positive integer constant (format I), will cause GENOVA to print out the first and last numrec input records. The default for GENOVA is to print out the first and last **1Ø** input records with their corresponding record means.

The 'NEGATIVE' parameter on an OPTIONS card specifies that when negative estimates for variance components occur, the actual negative estimates will be printed rather than '(Ø.Ø).' The default is not to print out the negative estimates.

The 'CORRELATION' parameter on an OPTIONS card specifies that the correlation matrix for estimated variance components is to be printed. The default is not to print this table.

Note: Since GCOMPONENTS and GMEANSQUARES runs do not read data records, the 'RECORDS' parameter only affects GSTUDY and STUDY runs.

The 'ECOLOGY' parameter on an OPTIONS card changes page ejects to four blank lines to conserve paper. The default in GENOVA is page ejects for each new output page.

The 'EMS' and 'ALGORITHM' parameters on an OPTIONS card specify which estimated variance components from the G-study are to be used in D-study processing. The default is EMS (Expected Mean Squares) variance components.

Note: EMS and Algorithm estimated variance components are identical if no negative estimates occurred in the G study.

The 'DTABLE' parameter on an OPTIONS card specifies that, for each D study, an optional output be produced consisting of the variance-covariance matrix for estimated variance components in the universe of generalization. The default is to not print out this variance-covariance matrix.

The OPTIONS card acts differently from any other GENOVA control card in that it can appear anywhere, and in that the options specified on this card remain in effect throughout a GENOVA execution unless they are reset.

The 'RESET' parameter on an OPTIONS card resets all OPTIONS card parameters back to their defaults: - no negative printing for estimated variance components, - no correlation table printing, - the printing of the first and last **10** input records on a GSTUDY or STUDY run, - perform full page ejects for each new output page printed, - use the EMS estimated variance components from the G study for D study processing, - and no variance-covariance matrix output for D studies.

Since the 'RECORDS' parameter specifies, for each GSTUDY or STUDY run, the number of input records to be printed out, it can be specified differently for each and every GSTUDY or STUDY run. Also, since the 'EMS' and 'ALGORITHM' options can change the estimated variance components to be used in a D study, they can be specified differently for each and every DSTUDY run.

The 'NEGATIVE', 'CORRELATION', 'ECOLOGY' and 'DTABLE' parameters, however, remain in effect until a 'RESET' parameter is specified on a subsequent OPTIONS card.

Note: The 'RESET' parameter can be followed by other parameters on the same OPTIONS card, for example:

```
OPTIONS     NEGATIVE CORRELATION

  . . .

  . . .

  . . .

OPTIONS     RESET   NEGATIVE RECORDS NONE
```

The first OPTIONS card turns on negative estimate and correlation table printing, but does not alter the number of input records to be printed out.

The second OPTIONS card turns off negative estimate printing and correlation table printing and sets the number of input records to be printed to **10**, all by the 'RESET' parameter. It

then turns the negative estimate printing option back on via the 'NEGATIVE' parameter and inhibits the printing of any input records via the 'RECORDS NONE' parameter.

Note: The position of the 'RESET' parameter on an OPTIONS card is **critical** since, when it is encountered, it resets all OPTIONS card parameters to their default values. Therefore, 'RESET' should always precede any other parameter on an OPTIONS card. If it does follow another parameter, no error message will be generated, but 'RESET' will void any parameters that preceded it by setting such parameters back to their default values.

OUTPUT Card

The OUTPUT control card redirects all GENOVA output to a different logical unit number.

Columns: 1-6 Variable: 'OUTPUT' Format: A

The card identifier 'OUTPUT' should appear in columns 1-6. Note that columns 1-4 must contain 'OUTP'.

Columns: variable Variable: KOUT Format: I

The user-supplied value for KOUT will specify the logical unit number that is to be used for output unless changed by later OUTPUT cards. If columns 13-80 are blank on the OUTPUT card, KOUT is defaulted to KFOUT - the standard GENOVA output logical unit. The distributed source code for GENOVA has KFOUT = 6.

The OUTPUT card can have no continuation cards.

PROCESS Card

The PROCESS card is used to indicate that all control cards have been input following a GSTUDY or STUDY card and that the actual processing can now begin.

Columns: 1-7 Variable: 'PROCESS' Format: A

The card identifier 'PROCESS' should appear in columns 1-7. Note that columns 1-4 must contain 'PROC'.

The general format of the data which can appear in columns 13-80 on a PROCESS card is the following:

[KDATA] ['DEFAULT']

Columns: variable Variable: KDATA Format: I
Default: KFDATA

KDATA is a user-supplied integer value specifying the logical unit number to be used for reading the input data. If KDATA is not specified on the PROCESS card, the default logical unit number 'KFDATA' (= to the default input unit number for control cards) will be used. The distributed source code for GENOVA has KFDATA = 5.

The literal 'DEFAULT' (without the apostrophes) when present on a PROCESS card, must follow KDATA (if specified). DEFAULT specifies that a default D study is to be performed after GSTUDY processing is complete. For a default D study, the starred facet becomes the object of measurement facet, and the G study sample and universe sizes are used as the D study sample and universe sizes.

Since it is possible that input data may immediately follow the PROCESS card, there can be no continuations of this control card.

Note: If a READ card is in effect (see description , below) then the default for KDATA = KINALT, i.e. the current logical unit number for inputting control cards.

READ Card

The READ card gives the GENOVA user a method of storing a series of control cards and possibly data on a separate file (terminated by a REVERT card) which can be accessed by simply issuing a READ card with the appropriate logical unit number (KINALT).

Columns: 1-4 Variable: 'READ' Format: A

The card identifier 'READ' should appear in columns 1-4.

The READ card must have exactly one parameter on it, KINALT, which is an integer, and the READ card can have no continuation cards attached to it.

Columns: variable Variable: KINALT Format: I

KINALT is a user-specified integer value representing a logical unit number to be used for reading control cards until a 'REVERT' control card is encountered (see description of REVERT control card below).

The READ card has the effect of forcing the GENOVA program to read logical unit 'KINALT' for control cards and/or data until further notice (a REVERT card).

Note: Only one READ card can be in effect at any one time; they cannot be nested: i.e. there can be no READ card in KINALT.

REWIND Card

The REWIND card can be used to rewind one or more logical files by specifying their logical unit numbers on the card.

Columns: 1-6 Variable: 'REWIND' Format: A

The card identifier 'REWIND' should appear in columns 1-6. Note that columns 1-4 must contain 'REWI'.

The format for the data area of the REWIND card (columns 13-80) is as follows:

LFN [,LFN,LFN, ... LFN]

Columns: variable Variable: LFN Format: I

The user-supplied values for LFN are integers representing the logical unit numbers of the files the user wishes rewound.

GENOVA will not allow you to rewind the standard input logical unit (KFIN = 5) or to rewind KINALT from within KINALT (see READ control card discussion). This is necessary to insure that the combination of READ and REWIND control cards cannot put GENOVA into an infinite loop. GENOVA will also not allow you to rewind the logical output unit.

If multiple LFN values are specified, they must be separated by at least one **comma** or **space**.

Continuation Cards: The REWIND card can have as many continuation cards as the user desires.

REVERT Card

The REVERT control card has no arguments, and has the effect of reverting to the previous (default) input logical unit (KFIN = 5) for reading control cards (see discussion of the READ control card). The REVERT card can only appear in KINALT, an alternate logical input unit. If it appears on the default input unit, an error message will be generated.

Columns: 1-6 Variable: 'REVERT' Format: A

The card identifier 'REVERT' should appear in columns 1-6. Note that columns 1-4 must contain 'REVE'.

The REVERT card can have no continuation cards. GENOVA ignores any information in columns 13-80 of a REVERT card.

STUDY Card

A STUDY card signals the beginning of a series of control cards which will specify a study to be performed from raw data. The last control card in this series is a PROCESS card. The STUDY control card is identical in function to a GSTUDY card and they can be used interchangeably.

Columns: 1-6 Variable: 'STUDY' Format: A

The card identifier 'STUDY' should appear in columns 1-6. Note that columns 1-4 must contain 'STUD'.

Columns: 13-80 Variable: KTITLE Format: A

KTITLE is a user-defined alphanumeric heading which will appear on each output page of the study results. Like the GMEANSQUARES and GCOMPONENTS cards, the STUDY card cannot have any continuation cards and KTITLE should not be enclosed in quotes.

KTITLE will appear as the primary heading on each output page of the results and, if it is blank, the heading will also be blank.

Note: The SUBHEADING card can be used in conjunction with the STUDY card to provide sub-headings as well as primary headings for the output (see description of the SUBHEADING card).

SUBHEADING Card

The SUBHEADING control card is a method for providing optional sub-headings for reports in addition to the title headings that are input on the 'GSTUDY', 'GMEANSQUARES', 'GCOMPONENTS', 'STUDY' AND 'DSTUDY' cards.

Columns: 1-10 Variable: 'SUBHEADING' Format: A

The card identifier 'SUBHEADING' should appear in columns 1-10. Note that columns 1-4 must contain 'SUBH'.

Columns: 13-80 Variable: KSUBH Format: A

KSUBH is a user-defined alphanumeric sub-heading that will be printed out as a secondary heading on all reports. Since KSUBH is printed out literally as it appears in columns 13-80 of the SUBHEADING card, no enclosing quotes are needed. If columns 13-80 are all blank, the sub-heading output will be inhibited.

Each time a GSTUDY, STUDY, GMEANSQUARES, GCOMPONENTS or DSTUDY card is read, KSUBH is set to blanks to insure that the sub-heading from a previous study is not used by accident.

Note: Since only 68 characters are stored in KSUBH, the SUBHEADING card cannot have any continuation cards. It should be noted that GENOVA will center the text of KSUBH when it is printed out by balancing leading and trailing blanks.

VCOMPONENT Card

The VCOMPONENT card provides the detailed input values required on a GCOMPONENTS run of GENOVA. The VCOMPONENT cards specify the variance components for all main and interaction effects, as well as the sample and universe (or population) sizes for the facet associated with the primary index in each main effect.

Columns: 1-10 Variable: 'VCOMPONENT' Format: A

The card identifier 'VCOMPONENT' should appear in columns 1-10. Note that columns 1-4 must contain 'VCOM'.

The two general formats for the data area (columns 13-80) of the VCOMPONENT card and its continuations are as follows:

Format 1: **FACET VCOMP NSAMP [NUNIV]**

Format 2: **MEFFCT VCOMP**

Format 1 of the VCOMPONENT card is used for the main effects the design (maximum of 6) and must come first. Format 2 is used for all of the interaction effects for the design.

Columns: variable Variable: MFACET Format: A

MFACET is a one-to-eleven character character-string describing a main effect for this study. MFACET can only contain letters (A-Z) and colons (':') to describe a main effect (see discussion of notation in the body of this manual). The colon is used to indicate nesting. MFACET must appear as the first data field of every format 1 VCOMPONENT card.

Columns: variable Variable: MEFFCT Format: A

MEFFCT is formed exactly like MFACET, but it will represent an interaction effect, rather than a main effect. MEFFCT must appear first on every format 2 VCOMPONENT card.

Columns: variable Variable: VCOMP Format: F

VCOMP will be a user-supplied real number specifying the value of the variance component associated with the respective main effect (MFACET on format 1) or interaction effect (MEFFCT on format 2). A VCOMP value must appear as the second data field on every VCOMPONENT card.

Columns: variable Variable: NSAMP Format: I

NSAMP is a user-supplied integer value indicating the number of levels of data which occurred for this facet in the study which gave rise to these variance components. NSAMP always

follows immediately after MFACET as the next data field on each format 1 VCOMPONENT card.

Columns: variable Variable: NUNIV Format: I
Default: Zero ==> Infinity

NUNIV is an optional user-specified integer value used to indicate the population or universe size for the facet specified on this VCOMPONENT card in the study which produced these variance components. Zero is the default value which implies an infinite universe for this facet.

Note: It is important to have accurate values for NSAMP and NUNIV to insure the appropriateness of the standard errors derived from this data, i.e., the NSAMP and NUNIV values must be those used in obtaining the estimated variance components. Furthermore, there must be a VCOMPONENT card for each effect in the full model, and each card must contain an estimated variance component or quadratic form.

Order of Input: The order of the VCOMPONENT cards is relatively simple, but very important: All format 1 cards for the main effects must precede the format 2 cards for the interaction effects. Any other ordering will result in an error and GCOMPONENTS processing will be terminated.

In addition, the format 1 cards must be ordered such that a nested facet is specified after the facets within which it is nested. For example, the VCOMPONENT card for **T** must precede the VCOMPONENT card for **I:T** in a **P x (I:T)** design and the VCOMPONENT cards for **A**, **B** and **C** must precede the VCOMPONENT card for **S:ABC** in an **S:(ABC)** design.

Suppose that the design for a particular study was **P x (I:T)**, or p crossed with i nested within t. There would have to be three format 1 VCOMPONENT cards (for P, T, and I:T) for the three main effects with I:T following T, followed by the two format 2 VCOMPONENT cards in either order for the two interaction effects (PT and PI:T).

RESTRICTION: NSAMP >= 2 and if NUNIV is not zero, NSAMP <= NUNIV.

RESTRICTION: A maximum of six format 1 VCOMPONENT cards can appear in a single GCOMPONENTS run of GENOVA. It should also be noted that format 2 VCOMPONENT cards must be specified for each possible interaction effect, or GENOVA cannot perform the GCOMPONENTS processing.

Continuation Cards: A VCOMPONENT card may have as many continuation cards as the user desires.

TABLE A.1

GENOVA Control Card Ordering

	COMMENT	DCUT	DEFECT	DSTUDY	EFFECT	ENDCOMP	ENDSTUDY	ENDMEAN	FINISH	FORMAT	GCOMPONENTS	GMEANSQUARES	GSTUDY	MEANSQUARE	NAME	OPTIONS	OUTPUT	PROCESS	READ	REWIND	REVERT	STUDY	SUBHEADING	VCOMPONENT
GSTUDY or STUDY Run					-					-			F		-	-	-	L	-	-	-	F	-	
GMEANSQUARES Run	-							L				F		-	-	-	-		-	-	-		-	
GCOMPONENTS Run	-					L					-				-	-	-		-	-	-		-	-
DSTUDY Run	-	-	-	F			L									-	-		-	-	-		-	
GSTUDY or STUDY[1]						*	*	*										*[2]						
GMEANSQUARES[1]						*	*	*										*[2]						
GCOMPONENTS[1]						*	*	*										*[2]						
DSTUDY						*	*	*										*[2]						
FINISH						*	*	*										*[2]						

LEGEND:

Top Table

- F — This is the <u>first</u> card in the specified set of control cards.
- L — This is the <u>last</u> card in the specified set of control cards.
- \- — This control card may occur in the specified set of control cards.
- blank — This control card may not appear in the specified set of control cards.

Bottom Table

- * — The control card on the left may immediately follow this control card in a GENOVA control card input stream.

[1] These control cards may be first in a GENOVA control card input stream.

[2] The PROCESS card may be optionally followed by data before the next control card.

APPENDIX B

OUTPUT FOR SIMPLE RUNS

The following pages provide a reduced listing of the output for GENOVA that is generated for the two simple runs shown in Figures 2.1 and 2.2 in Chapter 2. The content of the output is outlined below:

Page	Description
B-2	Title Page
B-3	Control card listing for Simple Run # 1 Expanded main and interaction effect table
B-4	Input record listing
B-5	Cell mean scores Sums of squares, mean squares and F-statistics
B-6	Variance components, standard errors Expected Mean Square Equations
B-7	Variance-covariance matrix Correlation matrix Final control card listing for Simple Run # 1
B-8	Control card listing for Simple Run # 2 Expanded main and interaction effect table
B-9	Input record listing
B-10	Cell mean scores
B-11	Cell mean scores Sums of squares, mean squares and F-statistics
B-12	Variance components and standard errors Expected mean square equations
B-13	Variance-covariance matrix Final control card listing for Simple Run # 2

```
 GGGGGGGGGG   EEEEEEEEEEEE  NN        NN    OOOOOOOO    VV        VV   AAAAAAAAAA
GGGGGGGGGGGG  EEEEEEEEEEEE  NNN       NN   OOOOOOOOOO   VV        VV  AAAAAAAAAAAA
GG         G  EE            NNNN      NN  OO        OO  VV        VV  AA        AA
GG            EE            NN NN     NN  OO        OO   VV      VV   AA        AA
GG            EE            NN  NN    NN  OO        OO   VV      VV   AA        AA
GG            EE            NN   NN   NN  OO        OO   VV      VV   AA        AA
GG            EE            NN    NN  NN  OO        OO    VV    VV    AA        AA
GG            EEEEEEEE      NN     NN NN  OO        OO    VV    VV    AA        AA
GG      GGGG  EEEEEEEE      NN      NNNN  OO        OO    VV    VV    AAAAAAAAAAAA
GG      GGGG  EE            NN       NNN  OO        OO     VV  VV    AAAAAAAAAAAA
GG        GG  EE            NN        NN  OO        OO     VV  VV    AA        AA
GG        GG  EE            NN        NN  OO        OO     VV  VV    AA        AA
GG        GG  EE            NN        NN  OO        OO      V  V     AA        AA
GG        GG  EE            NN        NN  OO        OO      VVVV     AA        AA
GGGGGGGGGGGG  EEEEEEEEEEEE  NN        NN   OOOOOOOOOO       VVVV     AA        AA
 GGGGGGGGGG   EEEEEEEEEEEE  NN        NN    OOOOOOOO         VV      AA        AA
```

A GENERAL PURPOSE ANALYSIS OF VARIANCE SYSTEM

GENOVA IS A FORTRAN IV PROGRAM FOR ANALYSIS OF VARIANCE
WITH BALANCED DESIGNS AND FOR GENERAILIZABILITY ANALYIS

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VERSION 2.1
AUGUST, 1983

NOTES:

GENOVA HAS BEEN CHECKED FOR ACCURACY OF OUTPUT; HOWEVER THE AUTHORS CAN MAKE NO ASSURANCES THAT THE PROGRAM IS TOTALLY WITHOUT ERROR

GENOVA WAS DEVELOPED IN PART UNDER CONTRACT NO. N00123-78-C-1206 WITH THE NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER (NPRDC); ROBERT L. BRENNAN PRINCIPAL INVESTIGATOR. GENOVA DOES NOT NECESSARILY REFLECT NPRDC POSITIONS OR POLICY, AND NO OFFICIAL ENDORSEMENT SHOULD BE IMPLIED.

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
         1234567890123456789012345678901234567890123456789012345678901234567890
STUDY       DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1
COMMENT
COMMENT     # RECORDS = 10
COMMENT     # VALUES PER RECORD = 12
COMMENT
OPTIONS     RECORDS ALL   CORRELATION
EFFECT      * P 10 0
EFFECT      + T 3 0
EFFECT      + I:T 4 0
FORMAT      (12F2.0)
PROCESS
```

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

EXPANDED MAIN AND INTERACTION EFFECT TABLE

(** = INFINITE)	P	T	I	PRIMARY INDICES	TOTAL NUMBER INDICES	DEGREES OF FREEDOM
SAMPLE SIZE	10	3	4			
UNIVERSE SIZE	****	****	****			
P	1	0	0	1	1	9
T	0	1	0	1	1	2
I:T	0	2	1	1	2	9
PT	1	1	0	2	2	18
PI:T	1	2	1	2	3	81

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

INPUT RECORD LISTING WITH RECORD MEANS

RECORD #	1	5.00000	6.00000	5.00000	5.00000	5.00000	3.00000	4.00000	5.00000
		6.00000	7.00000	3.00000	3.00000	4.75000			
RECORD #	2	9.00000	3.00000	7.00000	7.00000	7.00000	5.00000	5.00000	5.00000
		7.00000	7.00000	5.00000	2.00000	5.75000			
RECORD #	3	3.00000	4.00000	3.00000	3.00000	5.00000	3.00000	3.00000	5.00000
		6.00000	5.00000	1.00000	6.00000	3.91667			
RECORD #	4	7.00000	5.00000	5.00000	3.00000	3.00000	1.00000	4.00000	3.00000
		5.00000	3.00000	3.00000	5.00000	3.91667			
RECORD #	5	9.00000	2.00000	9.00000	7.00000	7.00000	7.00000	3.00000	7.00000
		2.00000	7.00000	5.00000	3.00000	5.66667			
RECORD #	6	3.00000	4.00000	3.00000	5.00000	3.00000	3.00000	6.00000	3.00000
		4.00000	5.00000	1.00000	2.00000	3.50000			
RECORD #	7	7.00000	3.00000	7.00000	7.00000	7.00000	5.00000	5.00000	7.00000
		5.00000	5.00000	5.00000	4.00000	5.58333			
RECORD #	8	5.00000	8.00000	5.00000	7.00000	7.00000	5.00000	5.00000	4.00000
		3.00000	2.00000	1.00000	1.00000	4.41667			
RECORD #	9	9.00000	9.00000	8.00000	8.00000	6.00000	6.00000	6.00000	5.00000
		5.00000	8.00000	1.00000	1.00000	6.00000			
RECORD #	10	4.00000	4.00000	4.00000	3.00000	3.00000	5.00000	6.00000	5.00000
		5.00000	7.00000	1.00000	1.00000	4.00000			

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

CELL MEAN SCORES

****

*** GRAND MEAN = 4.7500000 ***

****

MEAN SCORES FOR EFFECT: T SUBSCRIPT NOTATION: (T)

(1) =	5.500000	(2) =	4.800000	(3) =	3.950000

****

MEAN SCORES FOR EFFECT: I:T SUBSCRIPT NOTATION: (T,I)

(1,1) =	6.100000	(1,2) =	4.800000	(1,3) =	5.600000	(1,4) =	5.500000
(2,1) =	5.300000	(2,2) =	4.300000	(2,3) =	4.700000	(2,4) =	4.900000
(3,1) =	4.800000	(3,2) =	5.600000	(3,3) =	2.600000	(3,4) =	2.800000

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

STUDY RESULTS

(** = INFINITE)	P	T	I
SAMPLE SIZE	10	3	4
UNIVERSE SIZE	****	****	****

(QF = QUASI F RATIO)

EFFECT	DEGREES OF FREEDOM	SUMS OF SQUARES FOR MEAN SCORES	SUMS OF SQUARES FOR SCORE EFFECTS	MEAN SQUARES	F STATISTIC	F-TEST DEGREES OF FREEDOM NUMERATOR	DENOMINATOR
P	9	2800.16667	92.66667	10.29630	2.22935	9	18
T	2	2755.70000	48.20000	24.10000	2.17238 QF	2 QF	12 QF
I:T	9	2835.40000	79.70000	8.85556	3.72044	9	81
PT	18	2931.50000	83.13333	4.61852	1.94035	18	81
PI:T	81	3204.00000	192.80000	2.38025			
MEAN		2707.50000					
TOTAL	119		496.50000				

NOTE: FOR GENERALIZABILITY ANALYSES, F-STATISTICS SHOULD BE IGNORED

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

STUDY RESULTS

(** = INFINITE)	P	T	I
SAMPLE SIZE	10	3	4
UNIVERSE SIZE	****	****	****

QFM = QUADRATIC FORM

EFFECT	DEGREES OF FREEDOM	MODEL VARIANCE COMPONENTS USING ALGORITHM	USING EMS EQUATIONS	STANDARD ERROR
P	9	.4731481	.4731481	.3855758
T	2	.3251543	.3251543	.4379875
I:T	9	.6475309	.6475309	.3794056
PT	18	.5595679	.5595679	.3766291
PI:T	81	2.3802469	2.3802469	.3694860

NOTE: THE "ALGORITHM" AND "EMS" ESTIMATED VARIANCE COMPONENTS WILL BE IDENTICAL IF THERE ARE NO NEGATIVE ESTIMATES

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

EXPECTED MEAN SQUARE EQUATIONS

(** = INFINITE)	P	T	I
SAMPLE SIZE	10	3	4
UNIVERSE SIZE	****	****	****

EMS(P) = 1.00*VC(PI:T) + 4.00*VC(PT) + 12.00*VC(P)

EMS(T) = 1.00*VC(PI:T) + 4.00*VC(PT) + 10.00*VC(I:T) + 40.00*VC(T)

EMS(I:T) = 1.00*VC(PI:T) + 10.00*VC(I:T)

EMS(PT) = 1.00*VC(PI:T) + 4.00*VC(PT)

EMS(PI:T) = 1.00*VC(PI:T)

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

VARIANCE - COVARIANCE MATRIX FOR ESTIMATED VARIANCE COMPONENTS

	P	T	I:T	PT	PI:T
P	.1486687				
T	.0044439	.1918331			
I:T	0.0000000	-.0359871	.1439486		
PT	-.0444390	-.0141849	.0034130	.1418495	
PI:T	0.0000000	.0034130	-.0136520	-.0341300	.1365199

STUDY DATA SET 1 - RANDOM MODEL - P X (I:T) DESIGN - RUN 1

CORRELATION MATRIX FOR ESTIMATED VARIANCE COMPONENTS

	P	T	I:T	PT	PI:T
P	1.0000000				
T	.0263143	1.0000000			
I:T	0.0000000	-.2165619	1.0000000		
PT	-.3060135	-.0859908	.0238846	1.0000000	
PI:T	0.0000000	.0210900	-.0973855	-.2452585	1.0000000

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789
FINISH
```

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
STUDY       DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26
COMMENT
COMMENT     # RECORDS = 32
COMMENT     # VALUES/RECORD = 1
COMMENT
EFFECT      + A 2 0
EFFECT      + B 2 2
EFFECT      + C 2 2
EFFECT      * S:ABC 4 0
FORMAT      (F3.0)
PROCESS
```

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

EXPANDED MAIN AND INTERACTION EFFECT TABLE

(** = INFINITE)	A	B	C	S	PRIMARY INDICES	TOTAL NUMBER INDICES	DEGREES OF FREEDOM
SAMPLE SIZE	2	2	2	4			
UNIVERSE SIZE	****	2	2	****			
A	1	0	0	0	1	1	1
B	0	1	0	0	1	1	1
C	0	0	1	0	1	1	1
S:ABC	2	2	2	1	1	4	24
AB	1	1	0	0	2	2	1
AC	1	0	1	0	2	2	1
BC	0	1	1	0	2	2	1
ABC	1	1	1	0	3	3	1

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

INPUT RECORD LISTING WITH RECORD MEANS

RECORD #	1	3.00000	3.00000
RECORD #	2	6.00000	6.00000
RECORD #	3	3.00000	3.00000
RECORD #	4	3.00000	3.00000
RECORD #	5	4.00000	4.00000
RECORD #	6	5.00000	5.00000
RECORD #	7	4.00000	4.00000
RECORD #	8	3.00000	3.00000
RECORD #	9	7.00000	7.00000
RECORD #	10	8.00000	8.00000
RECORD #	23	4.00000	4.00000
RECORD #	24	3.00000	3.00000
RECORD #	25	5.00000	5.00000
RECORD #	26	6.00000	6.00000
RECORD #	27	5.00000	5.00000
RECORD #	28	6.00000	6.00000
RECORD #	29	10.00000	10.00000
RECORD #	30	10.00000	10.00000
RECORD #	31	9.00000	9.00000
RECORD #	32	11.00000	11.00000

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

CELL MEAN SCORES

****

*** GRAND MEAN = 5.3750000 ***

****

MEAN SCORES FOR EFFECT: A SUBSCRIPT NOTATION: (A)

(1) = 5.687500 (2) = 5.062500

****

MEAN SCORES FOR EFFECT: B SUBSCRIPT NOTATION: (B)

(1) = 3.125000 (2) = 7.625000

****

MEAN SCORES FOR EFFECT: C SUBSCRIPT NOTATION: (C)

(1) = 4.500000 (2) = 6.250000

****

MEAN SCORES FOR EFFECT: AB SUBSCRIPT NOTATION: (A,B)

(1,1) = 3.875000 (1,2) = 7.500000
(2,1) = 2.375000 (2,2) = 7.750000

****

MEAN SCORES FOR EFFECT: AC SUBSCRIPT NOTATION: (A,C)

(1,1) = 5.375000 (1,2) = 6.000000
(2,1) = 3.625000 (2,2) = 6.500000

****

MEAN SCORES FOR EFFECT: BC SUBSCRIPT NOTATION: (B,C)

(1,1) = 2.750000 (1,2) = 3.500000
(2,1) = 6.250000 (2,2) = 9.000000

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

CELL MEAN SCORES

****

MEAN SCORES FOR EFFECT: ABC SUBSCRIPT NOTATION: (A,B,C)

(1,1,1) =	3.750000	(1,1,2) =	4.000000
(1,2,1) =	7.000000	(1,2,2) =	8.000000
(2,1,1) =	1.750000	(2,1,2) =	3.000000
(2,2,1) =	5.500000	(2,2,2) =	10.000000

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

STUDY RESULTS

(** = INFINITE)	A	B	C	S
SAMPLE SIZE	2	2	2	4
UNIVERSE SIZE	****	2	2	****

(QF = QUASI F RATIO)

EFFECT	DEGREES OF FREEDOM	SUMS OF SQUARES FOR MEAN SCORES	SUMS OF SQUARES FOR SCORE EFFECTS	MEAN SQUARES	F STATISTIC	F-TEST DEGREES OF FREEDOM NUMERATOR	DENOMINATOR
A	1	927.62500	3.12500	3.12500	4.05405	1	24
B	1	1086.50000	162.00000	162.00000	26.44898	1	1
C	1	949.00000	24.50000	24.50000	2.41975	1	1
S:ABC	24	1160.00000	18.50000	.77083			
AB	1	1095.75000	6.12500	6.12500	7.94595	1	24
AC	1	962.25000	10.12500	10.12500	13.13514	1	24
BC	1	1119.00000	8.00000	8.00000	2.56000	1	1
ABC	1	1141.50000	3.12500	3.12500	4.05405	1	24
MEAN		924.50000					
TOTAL	31		235.50000				

NOTE: FOR GENERALIZABILITY ANALYSES, F-STATISTICS SHOULD BE IGNORED

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

STUDY RESULTS

(** = INFINITE)	A	B	C	S
SAMPLE SIZE	2	2	2	4
UNIVERSE SIZE	****	2	2	****

QFM = QUADRATIC FORM

EFFECT	DEGREES OF FREEDOM	MODEL VARIANCE COMPONENTS USING ALGORITHM	USING EMS EQUATIONS	STANDARD ERROR
A	1	.1471354	.1471354	.1600308
B	1	9.7421875 QFM	9.7421875 QFM	
C	1	.8984375 QFM	.8984375 QFM	
S:ABC	24	.7708333	.7708333	.2137907
AB	1	.6692708	.6692708	.6257011
AC	1	1.1692708	1.1692708	1.0337240
BC	1	.6093750 QFM	.6093750 QFM	
ABC	1	.5885417	.5885417	.6401232

NOTE: THE "ALGORITHM" AND "EMS" ESTIMATED VARIANCE COMPONENTS WILL BE IDENTICAL IF THERE ARE NO NEGATIVE ESTIMATES

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

EXPECTED MEAN SQUARE EQUATIONS

(** = INFINITE)	A	B	C	S
SAMPLE SIZE	2	2	2	4
UNIVERSE SIZE	****	2	2	****

EMS(A) = 1.00*VC(S:ABC) + 16.00*VC(A)

EMS(B) = 1.00*VC(S:ABC) + 8.00*VC(AB) + 16.00*VC(B)

EMS(C) = 1.00*VC(S:ABC) + 8.00*VC(AC) + 16.00*VC(C)

EMS(AB) = 1.00*VC(S:ABC) + 8.00*VC(AB)

EMS(AC) = 1.00*VC(S:ABC) + 8.00*VC(AC)

EMS(BC) = 1.00*VC(S:ABC) + 4.00*VC(ABC) + 8.00*VC(BC)

EMS(ABC) = 1.00*VC(S:ABC) + 4.00*VC(ABC)

EMS(S:ABC) = 1.00*VC(S:ABC)

STUDY DATA SET 5 - B AND C FIXED - S:(AXBXC) DESIGN - RUN 26

VARIANCE - COVARIANCE MATRIX FOR ESTIMATED VARIANCE COMPONENTS

	A	AB	AC	ABC	S:ABC
A	.0256099				
AB	.0003571	.3915019			
AC	.0003571	.0007142	1.0685853		
ABC	.0007142	.0014283	.0014283	.4097577	
S:ABC	-.0028567	-.0057133	-.0057133	-.0114266	.0457065

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
FINISH
```

APPENDIX C

OUTPUT FOR D STUDY RUNS

The following pages provide a paritial listing of the output for GENOVA that is generated for the sample run shown in Figure 3.1 in Chapter 3. The content of the output is outlined below:

Page	Description
C-2	Control card listing and Cell mean scores for the G Study
C-3	Sums of squares, mean squares and F-statistics Variance components, standard errors Variance-covariance matrix
C-4	Control card listing and D study partial output for first D study
C-5	D study summary for first set of D study control cards
C-6	Control card listing and D study partial output for second D study including cutting score output
C-7	D study summary for second set of D study control cards
C-8	Control card listing and D study partial output for third D study
C-9	D study optional variance-covariance matrix and D study summary for third set of D study control cards

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
GSTUDY      P X (I:R) DESIGN -- RANDOM MODEL
OPTIONS     RECORDS 2
EFFECT      * P 10 0
EFFECT      + R  3 0
EFFECT      + I:R 4 0
FORMAT       (12F2.0)
PROCESS
```

G STUDY — P X (I:R) DESIGN -- RANDOM MODEL
CELL MEAN SCORES

****

*** GRAND MEAN = 4.7500000 ***

****

MEAN SCORES FOR EFFECT: R — SUBSCRIPT NOTATION: (R)

(1) =	5.500000	(2) =	4.800000	(3) =	3.950000

****

MEAN SCORES FOR EFFECT: I:R — SUBSCRIPT NOTATION: (R,I)

(1,1) =	6.100000	(1,2) =	4.800000	(1,3) =	5.600000	(1,4) =	5.500000
(2,1) =	5.300000	(2,2) =	4.300000	(2,3) =	4.700000	(2,4) =	4.900000
(3,1) =	4.800000	(3,2) =	5.600000	(3,3) =	2.600000	(3,4) =	2.800000

G STUDY — P X (I:R) DESIGN -- RANDOM MODEL
ANOVA TABLE

(** = INFINITE)	P	R	I
SAMPLE SIZE	10	3	4
UNIVERSE SIZE	****	****	****

(QF = QUASI F RATIO)

EFFECT	DEGREES OF FREEDOM	SUMS OF SQUARES FOR MEAN SCORES	SUMS OF SQUARES FOR SCORE EFFECTS	MEAN SQUARES	F STATISTIC	F-TEST DEGREES OF FREEDOM NUMERATOR	DENOMINATOR
P	9	2800.16667	92.66667	10.29630	2.22935	9	18
R	2	2755.70000	48.20000	24.10000	2.17238 QF	2 QF	12 QF
I:R	9	2835.40000	79.70000	8.85556	3.72044	9	81
PR	18	2931.50000	83.13333	4.61852	1.94035	18	81
PI:R	81	3204.00000	192.80000	2.38025			
MEAN		2707.50000					
TOTAL	119		496.50000				

NOTE: FOR GENERALIZABILITY ANALYSES, F-STATISTICS SHOULD BE IGNORED

G STUDY — P X (I:R) DESIGN -- RANDOM MODEL
G STUDY RESULTS

(** = INFINITE)	P	R	I
SAMPLE SIZE	10	3	4
UNIVERSE SIZE	****	****	****

QFM = QUADRATIC FORM

EFFECT	DEGREES OF FREEDOM	MODEL VARIANCE COMPONENTS: USING ALGORITHM	USING EMS EQUATIONS	STANDARD ERROR
P	9	0.4731481	0.4731481	0.3855758
R	2	0.3251543	0.3251543	0.4379875
I:R	9	0.6475309	0.6475309	0.3794056
PR	18	0.5595679	0.5595679	0.3766291
PI:R	81	2.3802469	2.3802469	0.3694860

NOTE: THE "ALGORITHM" AND "EMS" ESTIMATED VARIANCE COMPONENTS WILL BE IDENTICAL IF THERE ARE NO NEGATIVE ESTIMATES

G STUDY — P X (I:R) DESIGN -- RANDOM MODEL
VARIANCE - COVARIANCE MATRIX FOR ESTIMATED VARIANCE COMPONENTS (V)

	P	R	I:R	PR	PI:R
P	0.1486687				
R	0.0044439	0.1918331			
I:R	0.0000000	-0.0359871	0.1439486		
PR	-0.0444390	-0.0141849	0.0034130	0.1418495	
PI:R	0.0000000	0.0034130	-0.0136520	-0.0341300	0.1365199

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
COMMENT     FIRST SET OF D STUDY CONTROL CARDS
DSTUDY      #1 -- P X (I:R) DESIGN -- I,R - RANDOM
DEFFECT     $ P
DEFFECT       R 3
DEFFECT       I:R 1 2 3 4
ENDDSTUDY
```

****
*** OUTPUT FOR D STUDIES WITH 1, 2, AND 3 ITEMS NOT INCLUDED BELOW ***
****

D STUDY #1 -- P X (I:R) DESIGN -- I,R - RANDOM

D STUDY DESIGN NUMBER 001-004

OBJECT OF MEASUREMENT :	P	FACETS :	R	I:R
G STUDY POPULATION SIZE :	INFINITE	G STUDY UNIVERSE SIZES :	INFINITE	INFINITE
D STUDY POPULATION SIZE :	INFINITE	D STUDY UNIVERSE SIZES :	INFINITE	INFINITE
D STUDY SAMPLE SIZE :	10	D STUDY SAMPLE SIZES :	3	4

	VARIANCE COMPONENTS IN TERMS OF G STUDY UNIVERSE (OF ADMISSIBLE OBSERVATIONS) SIZES					VARIANCE COMPONENTS IN TERMS OF D STUDY UNIVERSE (OF GENERALIZATION) SIZES				
				VARIANCE COMPONENTS FOR MEAN SCORES					VARIANCE COMPONENTS FOR MEAN SCORES	
EFFECT	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE COR-RECTIONS	D STUDY SAMPLING FRE-QUENCIES	ESTIMATES	STANDARD ERRORS	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE COR-RECTIONS	D STUDY SAMPLING FRE-QUENCIES	ESTIMATES	STANDARD ERRORS
P	0.47315	1.0000	1	0.47315	0.38558	0.47315	1.0000	1	0.47315	0.38558
R	0.32515	1.0000	3	0.10838	0.14600	0.32515	1.0000	3	0.10838	0.14600
I:R	0.64753	1.0000	12	0.05396	0.03162	0.64753	1.0000	12	0.05396	0.03162
PR	0.55957	1.0000	3	0.18652	0.12554	0.55957	1.0000	3	0.18652	0.12554
PI:R	2.38025	1.0000	12	0.19835	0.03079	2.38025	1.0000	12	0.19835	0.03079

QFM = QUADRATIC FORM

	VARIANCE	STANDARD DEVIATION	STANDARD ERROR OF VARIANCE
UNIVERSE SCORE	0.47315	0.68786	0.38558
EXPECTED OBSERVED SCORE	0.85802	0.92630	0.36586
LOWER CASE DELTA	0.38488	0.62038	0.12171
UPPER CASE DELTA	0.54722	0.73974	0.17935
MEAN	0.24815	0.49814	

GENERALIZABILITY COEFFICIENT = 0.55144 (1.22935)
PHI = 0.46370 (0.86464)

NOTE: SIGNAL/NOISE RATIOS ARE IN PARENTHESES

D STUDY #1 -- P X (I:R) DESIGN -- I,R - RANDOM

SUMMARY OF D STUDY RESULTS FOR SET OF CONTROL CARDS NO. 001

D STUDY DESIGN NO	INDEX= UNIV.=	SAMPLE SIZES $P INF.	R INF.	I INF.	VARIANCES UNIVERSE SCORE	EXPECTED OBSERVED SCORE	LOWER CASE DELTA	UPPER CASE DELTA	MEAN	GEN. COEF.	PHI
001-001		10	3	1	0.47315	1.45309	0.97994	1.30417	0.46954	0.32562	0.26622
001-002		10	3	2	0.47315	1.05638	0.58323	0.79954	0.32194	0.44790	0.37177
001-003		10	3	3	0.47315	0.92414	0.45099	0.63133	0.27275	0.51199	0.42839
001-004		10	3	4	0.47315	0.85802	0.38488	0.54722	0.24815	0.55144	0.46370

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
         12345678901234567890123456789012345678901234567890123456789012345678901
COMMENT     SECOND SET OF D STUDY CONTROL CARDS
DSTUDY      #2 -- I:R:P DESIGN -- I,R - RANDOM
DCUT                0.2 0.4 0.6 0.8 1.0
DEFFECT     $ P
DEFFECT       R:P 3
DEFFECT       I:R:P 1 2 3 4
ENDDSTUDY
```

```
*****************************************************************
*** OUTPUT FOR D STUDIES WITH 1, 2, AND 3 ITEMS NOT INCLUDED BELOW ***
*****************************************************************
```

```
D STUDY                          #2 -- I:R:P DESIGN -- I,R - RANDOM
                                   D STUDY DESIGN NUMBER 002-004
  OBJECT OF MEASUREMENT :      P                    FACETS :     R:P        I:R:P
G STUDY POPULATION SIZE : INFINITE     G STUDY UNIVERSE SIZES : INFINITE    INFINITE
D STUDY POPULATION SIZE : INFINITE     D STUDY UNIVERSE SIZES : INFINITE    INFINITE
  D STUDY SAMPLE SIZE :     10         D STUDY SAMPLE SIZES :     3          4
```

	VARIANCE COMPONENTS IN TERMS OF G STUDY UNIVERSE (OF ADMISSIBLE OBSERVATIONS) SIZES					VARIANCE COMPONENTS IN TERMS OF D STUDY UNIVERSE (OF GENERALIZATION) SIZES				
				VARIANCE COMPONENTS FOR MEAN SCORES					VARIANCE COMPONENTS FOR MEAN SCORES	
EFFECT	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE COR-RECTIONS	D STUDY SAMPLING FRE-QUENCIES	ESTIMATES	STANDARD ERRORS	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE COR-RECTIONS	D STUDY SAMPLING FRE-QUENCIES	ESTIMATES	STANDARD ERRORS
P	0.47315	1.0000	1	0.47315	0.38558	0.47315	1.0000	1	0.47315	0.38558
R:P	0.88472	1.0000	3	0.29491	0.18418	0.88472	1.0000	3	0.29491	0.18418
I:R:P	3.02778	1.0000	12	0.25231	0.04193	3.02778	1.0000	12	0.25231	0.04193

QFM = QUADRATIC FORM

	VARIANCE	STANDARD DEVIATION	STANDARD ERROR OF VARIANCE
UNIVERSE SCORE	0.47315	0.68786	0.38558
EXPECTED OBSERVED SCORE	1.02037	1.01013	0.39265
LOWER CASE DELTA	0.54722	0.73974	0.17935
UPPER CASE DELTA	0.54722	0.73974	0.17935
MEAN	0.10204	0.31943	

GENERALIZABILITY COEFFICIENT = 0.46370 (0.86464)
PHI = 0.46370 (0.86464)

DBAR = 4.750000

PHI (LAMBDA = 0.2000) = 0.97469 (38.51015)
PHI (LAMBDA = 0.6000) = 0.96983 (32.15076)
PHI (LAMBDA = 1.0000) = 0.96347 (26.37614)

PHI (LAMBDA = DBAR) = 0.40411 (0.67817)
PHI (LAMBDA = 0.4000) = 0.97242 (35.25736)
PHI (LAMBDA = 0.8000) = 0.96688 (29.19036)

NOTE: SIGNAL/NOISE RATIOS ARE IN PARENTHESES

D STUDY #2 -- I:R:P DESIGN -- I,R - RANDOM

SUMMARY OF D STUDY RESULTS FOR SET OF CONTROL CARDS NO. 002

D STUDY DESIGN NO	INDEX= UNIV.=	SAMPLE SIZES $P INF.	R INF.	I INF.	VARIANCES UNIVERSE SCORE	EXPECTED OBSERVED SCORE	LOWER CASE DELTA	UPPER CASE DELTA	MEAN	GEN. COEF.	PHI
002-001		10	3	1	0.47315	1.77731	1.30417	1.30417	0.17773	0.26622	0.26622
002-002		10	3	2	0.47315	1.27269	0.79954	0.79954	0.12727	0.37177	0.37177
002-003		10	3	3	0.47315	1.10448	0.63133	0.63133	0.11045	0.42839	0.42839
002-004		10	3	4	0.47315	1.02037	0.54722	0.54722	0.10204	0.46370	0.46370

CONTROL CARD INPUT LISTING

```
COLUMN   1111111111222222222233333333334444444444555555555566666666667777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
COMMENT     THIRD SET OF D STUDY CONTROL CARDS
DSTUDY      #3 -- P X (I:R) -- I - RANDOM, R - FIXED
OPTIONS     DTABLE
DEFFECT     $ P
DEFFECT       R 3 / 3
DEFFECT       I:R 1 2 3 4
ENDDSTUDY
```

```
*******************************************************************
*** OUTPUT FOR D STUDIES WITH 1, 2, AND 3 ITEMS NOT INCLUDED BELOW ***
*******************************************************************
```

```
D STUDY                          #3 -- P X (I:R) -- I - RANDOM, R - FIXED
                                     D STUDY DESIGN NUMBER 003-004
  OBJECT OF MEASUREMENT :      P                    FACETS :      R          I:R
G STUDY POPULATION SIZE : INFINITE     G STUDY UNIVERSE SIZES : INFINITE    INFINITE
D STUDY POPULATION SIZE : INFINITE     D STUDY UNIVERSE SIZES :     3       INFINITE
   D STUDY SAMPLE SIZE :    10         D STUDY SAMPLE SIZES :     3           4
```

	VARIANCE COMPONENTS IN TERMS OF G STUDY UNIVERSE (OF ADMISSIBLE OBSERVATIONS) SIZES					VARIANCE COMPONENTS IN TERMS OF D STUDY UNIVERSE (OF GENERALIZATION) SIZES				
				VARIANCE COMPONENTS FOR MEAN SCORES					VARIANCE COMPONENTS FOR MEAN SCORES	
EFFECT	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE CORRECTIONS	D STUDY SAMPLING FREQUENCIES	ESTIMATES	STANDARD ERRORS	VARIANCE COMPONENTS FOR SINGLE OBSERVATIONS	FINITE UNIVERSE CORRECTIONS	D STUDY SAMPLING FREQUENCIES	ESTIMATES	STANDARD ERRORS
P	0.47315	1.0000	1	0.47315	0.38558	0.65967	1.0000	1	0.65967	0.36716
R	0.32515	1.0000	3	0.10838	0.14600	0.32515QFM	0.0000	3	-------	-------
I:R	0.64753	1.0000	12	0.05396	0.03162	0.64753	1.0000	12	0.05396	0.03162
PR	0.55957	1.0000	3	0.18652	0.12554	0.55957	0.0000	3	-------	-------
PI:R	2.38025	1.0000	12	0.19835	0.03079	2.38025	1.0000	12	0.19835	0.03079

QFM = QUADRATIC FORM

	VARIANCE	STANDARD DEVIATION	STANDARD ERROR OF VARIANCE
UNIVERSE SCORE	0.65967	0.81220	0.36716
EXPECTED OBSERVED SCORE	0.85802	0.92630	0.36586
LOWER CASE DELTA	0.19835	0.44537	0.03079
UPPER CASE DELTA	0.25231	0.50231	0.04193
MEAN	0.13976	0.37385	

GENERALIZABILITY COEFFICIENT = 0.76882 (3.32573)
PHI = 0.72333 (2.61448)

NOTE: SIGNAL/NOISE RATIOS ARE IN PARENTHESES

D STUDY #3 -- P X (I:R) -- I - RANDOM, R - FIXED
D STUDY DESIGN NUMBER 003-004

VARIANCE - COVARIANCE MATRIX FOR ESTIMATED VARIANCE COMPONENTS (FOR MEAN SCORES) IN UNIVERSE OF GENERALIZATION (W)

	P	I:R	PI:R
P	0.1348038		
I:R	0.0000948	0.0009996	
PI:R	-0.0009481	-0.0000948	0.0009481

D STUDY #3 -- P X (I:R) -- I - RANDOM, R - FIXED

SUMMARY OF D STUDY RESULTS FOR SET OF CONTROL CARDS NO. 003

D STUDY DESIGN NO	SAMPLE SIZES INDEX= UNIV.=	$P INF.	R 3	I INF.	VARIANCES UNIVERSE SCORE	EXPECTED OBSERVED SCORE	LOWER CASE DELTA	UPPER CASE DELTA	MEAN	GEN. COEF.	PHI
003-001		10	3	1	0.65967	1.45309	0.79342	1.00926	0.36115	0.45398	0.39527
003-002		10	3	2	0.65967	1.05638	0.39671	0.50463	0.21356	0.62446	0.56658
003-003		10	3	3	0.65967	0.92414	0.26447	0.33642	0.16436	0.71382	0.66226
003-004		10	3	4	0.65967	0.85802	0.19835	0.25231	0.13976	0.76882	0.72333

APPENDIX D

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