Module 3: Concepts and Procedures in G Theory

Main topics

- Describing a one-facet model
- Running the programs
  - Using one facet design as the example
  - Spss program
  - Genova program

Review of concepts

- Universe score and multifaceted measurement error
  - Universe is defined by facets which can be fixed or random
- Relative and absolute decisions
  - Purpose/use of scores
  - Statistical methods involved
- G coefficients
  - V(p) / (V(p) + variance of measurement error)
- G and D studies

Describing the model

- Only one facet is involved in the design. For example, 5 tasks were administered to 50 students (p x t), or 2 raters reviewed 80 students' research papers (p x r).
- The facet is random.
- The universe to be generalized is defined as all the conditions of this single facet.

Q: What about measurement errors?

Describing the model: Equations

Take the p x i as an example:

- Observed score

$X_{pi} = \mu$ [grand mean]

$+ X_p - \mu$ [person effect]

$+ X_i - \mu$ [item effect]

$+ X_{pi} - X_p - X_i + \mu$ [residual effect]

- Variance

$V(X_{pi}) = V(\mu_p) + V(\mu_i) + V(\mu_{pi,e})$ or

$\sigma^2(X_{pi}) = \sigma^2_p + \sigma^2_i + \sigma^2_{pi,e}$

Calculating G coefficient(s)

- Take the p x i design (random effect) as an example

Effect	SS	MS	Expected MS	Est. VC using 1 item	Est. G/D Study V Components
Person(p)	SS_p	$MS_p = SS_p/df_p$	$E(MS_p) = \sigma^2_{pi,e} + n_i\sigma^2_p$	$\sigma^2_p = [MS_p - MS_{pi,e}]/n_i$	σ^2_p
Item(i)	SS_i	$MS_i = SS_i/df_i$	$E(MS_p) = \sigma^2_{pi,e} + n_p\sigma^2_i$	$\sigma^2_i = [MS_i - MS_{pi,e}]/n_p$	$\sigma^2_i/n_{i'}$
pi, e	$SS_{pi,e}$	$MS_{pi,e} = SS_{pi,e}/df_{pi}$	$E(MS_{pi,e}) = \sigma^2_{pi,e}$	$\sigma^2_{pi,e} = MS_{pi,e}$	$\sigma^2_{pi,e}/n_{i'}$

Notations again

- Error variances
  - $\sigma^2(\delta)$ refers to relative error
  - $\sigma^2(\Delta)$ refers to absolute error
- G coefficients
  - ρ^2 refers to relative G coefficient
  - ϕ refers to absolute G coefficient

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Running the Programs to Conduct G and D Studies

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Three main ways

- Obtain the ANOVA results and then calculate the variance components – an indirect way

Two direct ways

- Run the SPSS - Variance Components
- Run the Genova

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Obtain the EMS from the anova output

- You can run the anova or scale in spss

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Comparison of SPSS and Genova

- When SPSS
  - Data structure has all the scores of all test takers just in a column
  - Includes missing value
  - Only handles the crossed design
- When Genova
  - Data structure has all the scores of one test taker in a row
  - Does not include any missing values
  - Involves the nested design (or crossed design)

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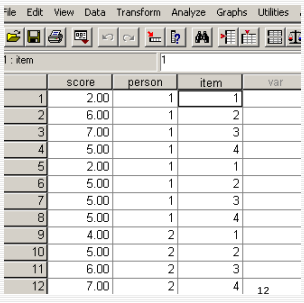
Running SPSS: data preparation

The data should be organized using the structure for running anova, e.g.,

- A column for item scores
- A column for stu id
- A column for item id



	score	person	item	var
1	2.00	1	1	
2	6.00	1	2	
3	7.00	1	3	
4	5.00	1	4	
5	2.00	1	1	
6	5.00	1	2	
7	5.00	1	3	
8	5.00	1	4	
9	4.00	2	1	
10	5.00	2	2	
11	6.00	2	3	
12	7.00	2	4	

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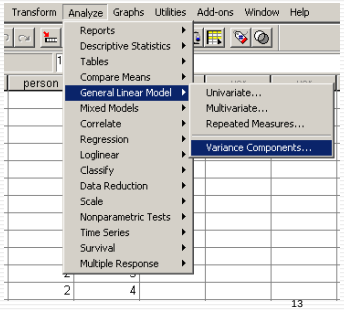
Running SPSS: analyzing

Use the menu to run the analysis

(1) Analyze -> GLM -> Variance Components…



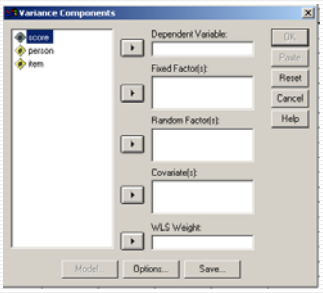
Running SPSS: analyzing

Then, you will see a small window

You need to:

(1) Select "score" as Dependent Variable;

(2) Select person and item as "Random Factor(s)"



The result!

- Identify the three variance components from your SPSS output
- Use Excel to calculate
  - the relative and absolute measurement errors
  - the relative and absolute coefficients

Variance Estimates

Component	Estimate
Var(item)	.969
Var(person)	.824
Var(item * person)	1.540
Var(Error)	.000[a]

Dependent Variable: score
Method: Minimum Norm Quadratic Unbiased Estimation (Weight = 1 for Random Effects and Residual)
a. This estimate is set to zero because it is redundant.

Try with mini-project 1 data

- Now use the spss VC to generate the G study results when using only one judge with your homework data

Mini-project 1 again: go through the genova program with the data

- Now use the genova to generate the G study results when using only one judge with project 1 data

One Facet Model: Cross and Nested Design

Main topics

- Review of the crossed design
  - Sharing your output
  - Interpreting the results from Genova
- Basic descriptions of the nested design
  - Describing the model
  - Estimating the G coefficient(s)
- Comparison of the crossed and nested designs
  - Ways to identify the variance components
  - Homework problems

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Interpret the Genova output (1)

Pages for you to double check your program

- P1 - show a proportion of your card file
- P2 - indicate the design and df
- P3 - list the scores
- P4 - print the means

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Interpret the Genova output (2)

Pages about the process of estimating the VCs

- P5 – report the anova results
- P6 - two procedures for estimating the VCs and SEs
- P7 - equations that link estimated MS with variances
- P8 - variance-covariance matrix

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Interpret the Genova output (3)

Pages that report the G/D study results

- P9 - another proportion of your card file
- P10 - the output of your G study
  - It includes all the information that you need.
- Other pages related to D studies and summaries

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Intro of the Nested Design

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Describe the model

- Only one facet is involved in the design. For example, each of the 50 students took a different set of 10 items (i:p), 20 research papers submitted to a journal and each was reviewed by 2 different reviewers (r:p).
- The universe to be generalized is defined as conditions from one single facet.

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Describe the model: examples

Determine what G design can be used to estimate the reliability.

- A set of four tasks were given to 30 students.
- In a study to evaluate teachers' effectiveness, each of 50 teachers randomly selected from WA state was observed by a different researcher.
- 30 students were administered a different set of two essay items.
- In a wine competition, each type of wine was evaluated by four judges.

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Describe the model: equations

Take the i:p as an example:

- Observed score

$X_{i:p} = \mu$ [grand mean]

$+ \mu_p - \mu$ [person effect]

$+ X_{i:p} - \mu_p$ [residual effect]

- Variance

$V(X_{i:p}) = V(\mu_p) + V(\mu_{i:p,e})$ or

$\sigma^2(X_{i:p}) = \sigma^2_p + \sigma^2_{i:p,e}$

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Estimate G coefficient(s)

- Take the i:p design (random effect) as an example

Effect	SS	MS	Expected MS	Est. VC Using 1 item	Est. G/D Study VC
Person(p)	SS_p	$MS_p = SS_p/df_p$	$E(MS_p) = \sigma^2_{i:p,e} + n_i\sigma^2_p$	$\sigma^2_p = [MS_p - MS_{i:p}]/n_i$	σ^2_p
res (i:p,e)	$SS_{i:p,e}$	$MS_{i:p} = SS_{i:p}/df_{i:p}$	$E(MS_{i:p}) = \sigma^2_{i:p,e}$	$\sigma^2_{i:p,e} = MS_{i:p}$	$\sigma^2_{i:p,e}/n_i'$

G coefficient = $\sigma^2_p/(\sigma^2_p + \sigma^2_{i:p,e})$

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Final note on the nested design

The nested design is

- not possible to obtain a separate estimate for all the variance components, such as V(i)
- less flexible in the D studies

Then, why nested design?

- Logistic concerns
- Some designs by nature are nested

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Ways to identify variance components: notation

Rules

- When a facet (B) is nested with another facet (A), B:A, this means that main effect of B cannot be a stand alone. It is always subsumed in B:A.

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Ways to identify variance components: notation

p x (i:t)

- Start with the nested part
- Decompose the nested part as two
  - t is a main effect and i is nested with t, so we should expect t main effect plus i:t nested effect.
- Continue with cross design
  - Since p is cross with (i:t), we should expect: p main effect, p cross with t, and p cross with i:t.
  - Regarding notations, they are p, pt, and i:pt, e.

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Now your turn

i:t:p p x (r:i)

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Ways to identify variance components: diagram

Rules:

- Each circle represents a facet.
- When two facets are crossed, the two circles are overlapped.
- When one facet (B) is nested within another facet (A), then Circle B is completely covered (or included) by Circle A.

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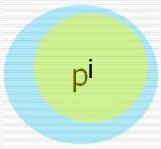
Ways to identify variance components: diagram

Persons (p) were given a set of items (i).



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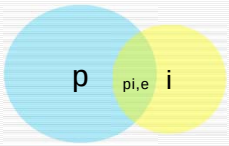
Ways to identify variance components: diagram

p x i -

persons were given the same set of items.



How many colors do we have now?

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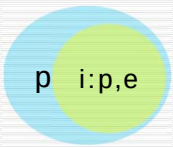
Ways to identify variance components: diagram

i:p -

persons were given different sets of items.



How many colors do we have now?

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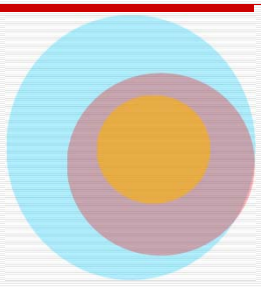
Let's figure out p x (i:t)

P

t



i

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Now your turn

i:t:p p x (r:i)

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Compare Crossed and Nested Designs

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If time allows (see the example that I pass out), let's compare the crossed and nested models …

- Run two D studies from a p x j design using the data in mini-project 1.
  - First D study includes 3 judges, using p x j design.
  - Second D study includes 3 judges too, using j:p design.
  - Compare the two sets of D study outputs.
    - What is the relationship between p variance?
    - What is the relationship between the abs. G coefficient?
    - Any other relationship?

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Planning: what data do you have?

- Go and check the data file that you have
- Start to describe the measurement procedure involved
  - what facets are you interested in investigating?
  - are they crossed or nested?
  - what design will you consider in your G study?

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