Chapter 14:
Nested & Split-plot Designs

Class 24, 5/6/09 W

Slide 1 Chapter 14:

Nested & Split-plot Designs

NOTES:

HW 16 due Tues 5/12/09 Noon

Submit as Myname-HW16.doc (or *.rtf)

- Read Chapter 14 Multifactor studies without replication
- For Weds read Chapter 23: Elements of Research Design
- For Monday Chapters 18-19: Comparisons of Proportions or Odds
- Final Class: Weds May 13 Research designs Designs
- Class schedule May 6 (Nesting and Experimental Designs), May 11 (Overview of generalized linear models) Exptl design May 13 W Last class
- Wimba Sessions: new times: Monday night 8 pm-9
- Homework 16: Due Tuesday 5/12/09 Noon
- Final Exam 5/22/09 Friday 8-11 am. This is the official time
  - Or 5/19/09 Tuesday 8-11 am. I'll find a room

Slide 2 HW 16 due Tues 5/12/09 Noon

NOTES:

Display 23.4

Checklist of tasks involved in the design of a study

- ☐ 1. State the objective. *What is the question of interest?*
- ☐ 2. Determine the scope of inference.
  - *Will this be a randomized experiment or an observational study?*
  - *What experimental or sampling units will be used?*
  - *What are the populations of interest?*
- ☐ 3. Understand the system under study.
- ☐ 4. Decide how to measure a response.
- ☐ 5. List factors that can affect the response.
  - Design factors
    - Factors to vary (treatments & controls)
    - Factors to fix
  - Confounding factors
    - Factors to control by design (blocking)
    - Factors to control by analysis (covariates)
    - Factors to control by randomization
- ☐ 6. Plan the conduct of the experiment (time line).
- ☐ 7. Outline the statistical analysis.
- ☐ 8. Determine the sample size ← Attempt this

last
ork (16),
is due
ay 5/12
moved
5/11)

Slide 3

NOTES:

Nested (=hierarchical) ANOVA

A) Testing the Chimp Gender Effect
B) Testing abundances on the Skagit flats
C) Testing the Spock Judge Effect (Case 5.2)
D) Testing airplane training facilities

Slide 4 Nested (=hierarchical) ANOVA

NOTES:

Pseudoreplication= model misspecification

Pseudoreplication: tests using an inappropriate error MS

- 8 buckets enclosing areas of the Skagit intertidal zone
- 4 treatments (2 buckets per trreatment)
  - Ambient (only buckets)
  - 50 *Eogammarus*
  - 25 Crangon
  - 300 *Eogammarus*
- 8 0.9-cm² cores per bucket after 3 days, 64 total samples
- Is there a treatment effect:
  - Did predators reduce oligochaete abundance?

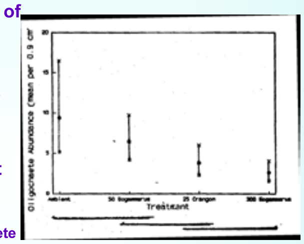
Slide 5 Pseudoreplication= model misspecification

NOTES:

Nested design (Experimental units [buckets] nested within treatment)

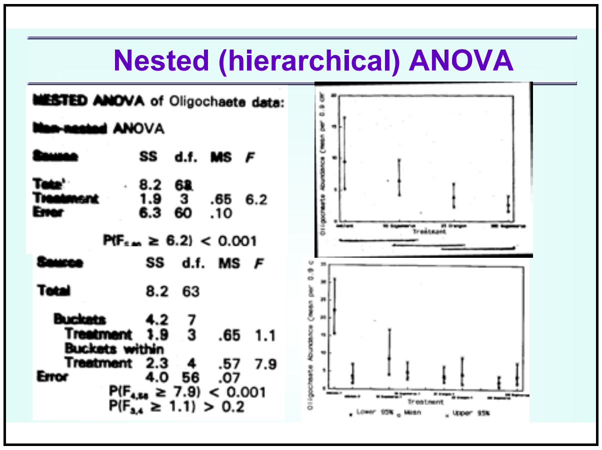
Can't be handled as a simple One-way ANOVA

- 8 buckets enclosing areas of the sandy intertidal on the Skagit flats
- 4 treatments
  - Ambient (bucket, no predators)
  - 50 *Eogammarus*
  - 25 *Crangon*
  - 300 *Eogammarus*
- 8 0.9-cm² cores per bucket after 3 days
- Is there a treatment effect:
  - Did predators reduce oligochaete abundance?



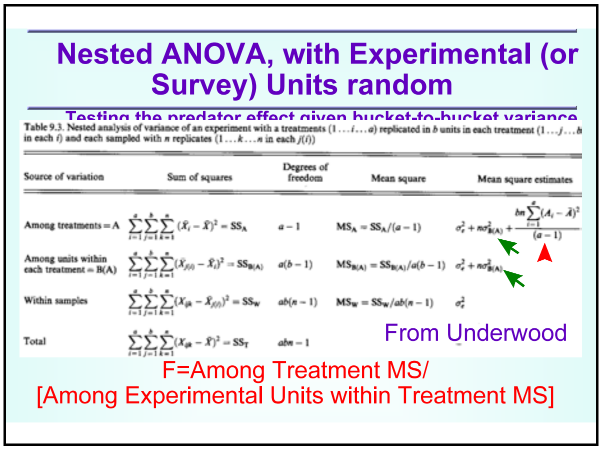
Slide 6 Nested design (Experimental units [buckets] nested within treatment)

NOTES:



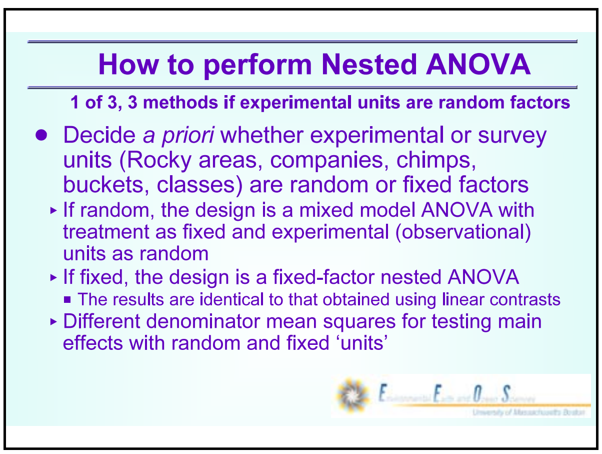
Slide 7 Nested (hierarchical) ANOVA

NOTES:



Slide 8 Nested ANOVA, with Experimental (or Survey) Units random

NOTES:



Slide 9 How to perform Nested ANOVA

NOTES:

How to perform a Nested ANOVA

2 of 3

- Method 1: A tried-and-true method: perform analyses as separate one-way ANOVAs
  - 1) Test for differences among experimental units to produce 'among Experimental Units' SS [and df] {differences among the 8 buckets in the Skagit example}
  - 2) Combine experimental units within treatments and perform 1-way ANOVA to produce among treatment SS [and df]
  - 3) subtract Among Treatment SS from 'Among experimental units SS' to produce 'Units within treatment' SS [and df]
  - 4) Calculate Mean squares by dividing by df
  - 5) Test treatment effects
    - A) Mixed model (Units as random factors): F Test Among treatment MS/'Units within Treatment' MS
    - B) Fixed model: Test Among treatment MS/'Error MS'

Slide 10 How to perform a Nested ANOVA

NOTES:

How to perform a Nested ANOVA

3 of 3

- Method 2: Alternatively for mixed model, calculate the mean response within each experimental unit and perform the 1-way ANOVA on the means
  - Hurlbert (1984) noted that nested ANOVAs are identical to performing ANOVAs on the unit means
- Method 3: SPSS. Must use syntax to specify the nested or hierarchical ANOVA tests.

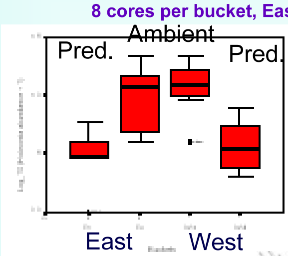
```
* Case 1401.
UNIANOVA
lnmin BY sign chimp sex
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/CRITERIA = ALPHA(.05)
/RANDOM=chimp
/DESIGN = sign sex chimp(sex) .
```

Slide 11 How to perform a Nested ANOVA

NOTES:

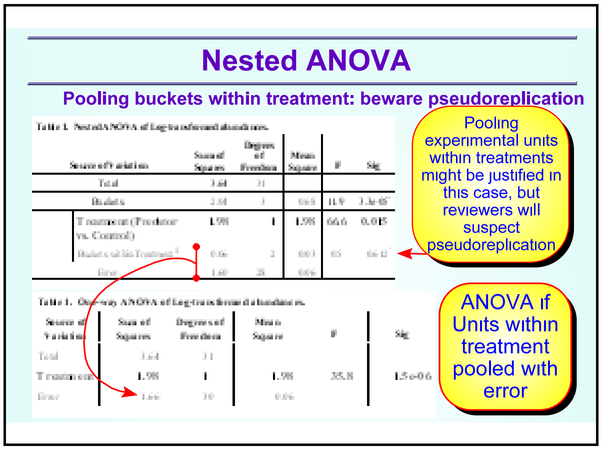
Effects of predation on *Hobsonia*

8 cores per bucket, Eastern & Western Blocks



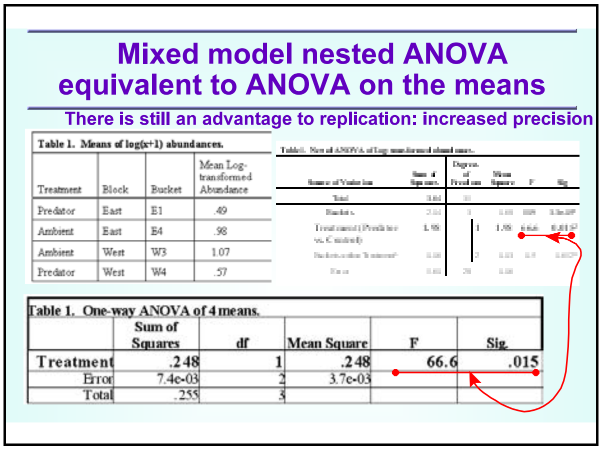
Slide 12 Effects of predation on Hobsonia

NOTES:



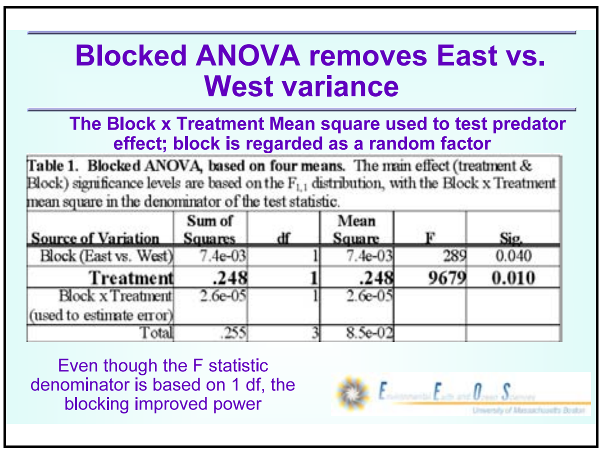
Slide 13 Nested ANOVA

NOTES:



Slide 14 Mixed model nested ANOVA equivalent to ANOVA on the means

NOTES:



Slide 15 Blocked ANOVA removes East vs. West variance

NOTES:

Nesting vs. Blocked ANOVA

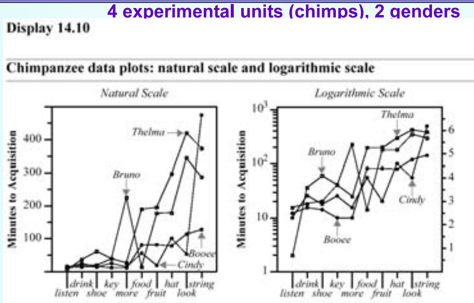
- Nesting: subsamples from experimental units can **not** be treated as replicates (pooling may be permissable only if "Exptl Units within Treatment MS has p>0.5, see Winer et al.)
- In designing an experiment or survey with a nested structure, investigator should strive to replicate experimental or survey units, **not** subsamples of experimental or survey units
- The final df will be partitioned as if only the means for each experimental unit were analyzed
  - There is a huge benefit from taking replicate subsamples in that the estimated means will be less variable (Avg/√n, central limit theorem)
- Blocking usually produces a more powerful design

Slide 16 Nesting vs. Blocked ANOVA

NOTES:

Is there a gender difference in learning?

4 experimental units (chimps), 2 genders



Slide 17 Is there a gender difference in learning?

NOTES:

Chimp Nested ANOVA

Sex is a 0,1 indicator variable
Chimp is the experimental unit, chimp variability nested within gender

```
UNIANOVA
lnmin  BY sign chimp sex
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/CRITERIA = ALPHA(.05)
/RANDOM=chimp
/DESIGN = sign sex chimp within sex.
```

```
* Or,
UNIANOVA
lnmin  BY sign chimp sex
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/CRITERIA = ALPHA(.05)
/RANDOM=chimp
/DESIGN = sign sex chimp(sex) .
```

The two italicized syntax lines specify identical nested analyses.

Slide 18 Chimp Nested ANOVA

NOTES:

If chimps random, test gender effect over 'among chimp within gender' mean square

If chimps are a random sample of chimps within gender, no effect of gender (p=0.82) on time to learn signs

Tests of Between-Subjects Effects

Dependent Variable: ln(Minutes)

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	615.158	1	615.158	238.173	.004
	Error	5.166	2	2.583[a]		
sign	Hypothesis	45.690	9	5.077	7.765	1.50E-005
	Error	17.653	27	.654[b]		
sex	Hypothesis	.167	1	.167	.065	.823
	Error	5.166	2	2.583[a]		
chimp(sex)	Hypothesis	5.166	2	2.583	3.950	.031
	Error	17.653	27	.654[b]		

a. MS(chimp(sex))
b. MS(Error)

Note, there is evidence for significant chimp-within-gender variance (p=0.031)

Slide 19 If chimps random, test gender effect over 'among chimp within gender' mean square

NOTES:

Chimps should be regarded as a fixed not a random factor

Test treatment over error mean square, see Neter et al. (1996)
Note that nested ANOVAs are usually handled as mixed models with experimental or survey units being random not fixed effects. These 4 chimps could not be regarded as random or even representative samples of a larger chimp population, so chimp within gender variability should be a fixed factor and inferences to a larger chimp population are not warranted.

Tests of Between-Subjects Effects

Dependent Variable: ln(Minutes)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	51.023[a]	12	4.252	6.50	2.8E-005
Intercept	615.158	1	615.158	940.90	1.6E-022
sign	45.690	9	5.077	7.76	1.5E-005
sex	.167	1	.167	.26	.617
chimp(sex)	5.166	2	2.583	3.95	.031
Error	17.653	27	.654		
Total	683.834	40			
Corrected Total	68.675	39			

a. R Squared = .743 (Adjusted R Squared = .629)

No gender effect

Slide 20 Chimps should be regarded as a fixed not a random factor

NOTES:

Nested ANOVA with chimp as a fixed effect is identical to a linear contrast on sex (specified *a priori*)

- UNIANOVA
- lnmin BY sign chimp
- /METHOD = SSTYPE(3)
- /LMatrix = "Male v. Female " chimp 1/2 1/2 -1/2 -1/2
- /INTERCEPT = INCLUDE
- /CRITERIA = ALPHA(.05)
- /DESIGN = sign chimp.

The denominator for Treatment F test is the error mean square

Slide 21 Nested ANOVA with chimp as a fixed effect is identical to a linear contrast on sex (specified a priori)

NOTES:

Results of testing gender effect using linear contrast: chimp 1/2 1/2 -1/2 -1/2

Contrast Results (K Matrix[a])

Contrast			Dependent Variable ln(Minutes)
L1		Contrast Estimate	-0.13
		Hypothesized Value	.00
		Difference (Estimate - Hypothesized)	-0.13
		Std. Error	.26
		Sig.	.62
	95% Confidence Interval for Difference	Lower Bound	-0.65
		Upper Bound	0.40

a. Based on the user-specified contrast coefficients (L') matrix: Male Female

Slide 22 Results of testing gender effect using linear contrast: chimp ½ ½ -1/2 -1/2

NOTES:

Neter et al. On distinguishing between crossed and nested designs

Slide 23 Neter et al. On distinguishing between crossed and nested designs

NOTES:

Nested *vs.* Crossed Factors

Neter et al.'s (1996) cities and airport mechanic training school example: mechanic training in schools in Atlanta, Chicago & San Francisco (2 instructors per school x 2 classes per instructor)

nested.sav - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Util

1 : Score 25

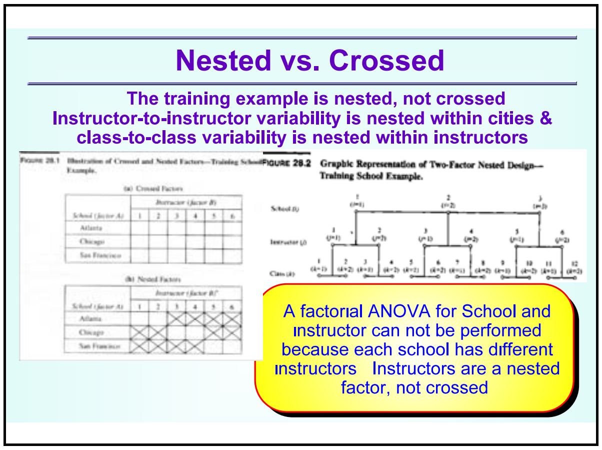
	Score	instructor	city
1	25	1	Atlanta
2	29	1	Atlanta
3	14	2	Atlanta
4	11	2	Atlanta
5	11	3	Chicago
6	6	3	Chicago
7	22	4	Chicago
8	18	4	Chicago
9	17	5	San Francisco
10	20	5	San Francisco
11	5	6	San Francisco
12	2	6	San Francisco

TABLE 28.1 Sample Data for Nested Two-Factor Study—Training School Example (class learning scores, coded).

Factor A (school) i		Factor B (instructor) j: 1	2	Average
Atlanta		25	14	
		29	11	
	Average	$\bar{Y}_{11.} = 27$	$\bar{Y}_{12.} = 12.5$	$\bar{Y}_{1..} = 19.75$
Chicago		11	22	
		6	18	
	Average	$\bar{Y}_{21.} = 8.5$	$\bar{Y}_{22.} = 20$	$\bar{Y}_{2..} = 14.25$
San Francisco		17	5	
		20	2	
	Average	$\bar{Y}_{31.} = 18.5$	$\bar{Y}_{32.} = 3.5$	$\bar{Y}_{3..} = 11.00$
			Average	$\bar{Y}_{...} = 15$

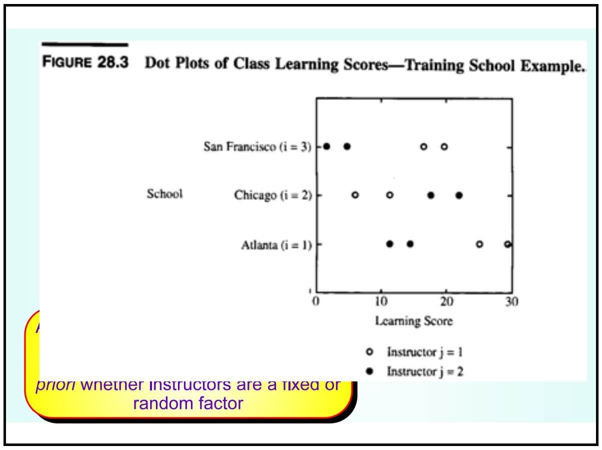
Slide 24 Nested vs. Crossed Factors

NOTES:



Slide 25 Nested vs. Crossed

NOTES:



Slide 26

NOTES:

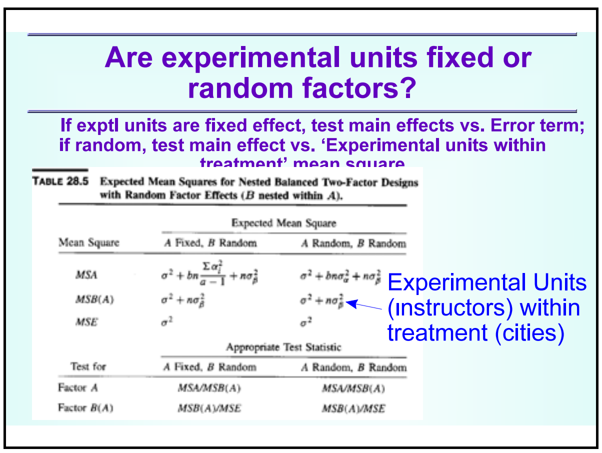


TABLE 28.5 Expected Mean Squares for Nested Balanced Two-Factor Designs with Random Factor Effects (B nested within A).

Mean Square	Expected Mean Square: A Fixed, B Random	Expected Mean Square: A Random, B Random
MSA	$\sigma^2 + bn\frac{\Sigma\alpha_i^2}{a-1} + n\sigma_\beta^2$	$\sigma^2 + bn\sigma_\alpha^2 + n\sigma_\beta^2$
$MSB(A)$	$\sigma^2 + n\sigma_\beta^2$	$\sigma^2 + n\sigma_\beta^2$
MSE	σ^2	σ^2

Test for	Appropriate Test Statistic: A Fixed, B Random	Appropriate Test Statistic: A Random, B Random
Factor A	$MSA/MSB(A)$	$MSA/MSB(A)$
Factor $B(A)$	$MSB(A)/MSE$	$MSB(A)/MSE$

Slide 27 Are experimental units fixed or random factors?

NOTES:

Two-factor Fixed Effects model

Neter et al. (1996) consider instructors to be a fixed effect, not a random effect

TABLE 28.3 ANOVA Table for Nested Balanced Two-Factor Fixed Effects Model (28.7) (B nested within A).

Source of Variation	SS	df	MS	E{MS}
Factor A	$SSA = bn\Sigma(\bar{Y}_{i..} - \bar{Y}_{...})^2$	$a-1$	MSA	$\sigma^2 + bn\frac{\Sigma\alpha_i^2}{a-1}$
Factor B (within A)	$SSB(A) = n\Sigma\Sigma(\bar{Y}_{ij.} - \bar{Y}_{i..})^2$	$a(b-1)$	$MSB(A)$	$\sigma^2 + n\frac{\Sigma\Sigma\beta_{j(i)}^2}{a(b-1)}$
Error	$SSE = \Sigma\Sigma\Sigma(Y_{ijk} - \bar{Y}_{ij.})^2$	$ab(n-1)$	MSE	σ^2
Total	$SSTO = \Sigma\Sigma\Sigma(Y_{ijk} - \bar{Y}_{...})^2$	$abn-1$		

Test for City effect over error mean square, not over instructor within city mean square

Slide 28 Two-factor Fixed Effects model

NOTES:

Example. Based on the analysis of variance in Table 28.4a for the training school example, we conduct the first test to determine whether or not main school effects exist. The alternatives are given in (28.17a), and test statistic (28.17b) here is:

$$F^* = \frac{78.25}{7.00} = 11.2$$

Strong evidence that the schools differ in learning effects.

For level of significance $\alpha = .05$, we require $F(.95; 2, 6) = 5.14$. Since $F^* = 11.2 > 5.14$, we conclude that the three schools differ in mean learning effects. The P-value of the test is .0094.

Next is a test for differences in mean learning effects between instructors within each school. The alternatives are given in (28.18a), and test statistic (28.18b) here is:

$$F^* = \frac{189.17}{7.00} = 27.0$$

Strong evidence for differences among instructors within schools.

For $\alpha = .05$, we require $F(.95; 3, 6) = 4.76$. Since $F^* = 27.0 > 4.76$, we conclude that instructors within at least one school differ in terms of mean learning effects. The P-value of this test is .0007.

Slide 29

NOTES:

This example: Fixed factor (Model I) nested ANOVA

- Neter et al. (1996) analyze the City and instructor problem as a Model I or fixed effects Nested ANOVA
- If the goal is to assess whether there are differences in the quality of the city training facilities (rather than the instructors), the model should probably be analyzed as a mixed model ANOVA, with instructors as random factors
  - Note that there is no evidence that instructors are a random sample of some larger population of instructors, so the fixed model is appropriate here
  - The inference can **not** be made that the city effect would be observed with a different set of instructors
- With a mixed model nested ANOVA, the city effect is assessed vs. 'instructors within city' MS

Slide 30 This example: Fixed factor (Model I) nested ANOVA

NOTES:

Instructors as fixed factors

UNIANOVA score BY city instructor
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/CRITERIA = ALPHA(.05)
/DESIGN = city instructor(city)

nested.sav - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utili

1 : Score 25

	Score	instructor	city
1	25	1	Atlanta
2	29	1	Atlanta
3	14	2	Atlanta
4	11	2	Atlanta
5	11	3	Chicago
6	6	3	Chicago
7	22	4	Chicago
8	18	4	Chicago
9	17	5	San Francisco
10	20	5	San Francisco
11	5	6	San Francisco
12	2	6	San Francisco

Tests of Between-Subjects Effects

Dependent Variable: Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	**724.000**[a]	**5**	**144.800**	**20.686**	**.001**
Intercept	**2700.000**	**1**	**2700.000**	**385.714**	**.000**
city	**156.500**	**2**	**78.250**	**11.179**	**.009**
instructor(city)	567.500	3	189.167	27.024	.001
Error	42.000	**6**	**7.000**		
Total	3466.000	12			
Corrected Total	766.000	11			

a. R Squared = .945 (Adjusted R Squared = .899)

Slide 31 Instructors as fixed factors

NOTES:

Instructors as random factors

Permits inferences beyond these 6 instructors, if these instructors can be regarded as random samples from a larger pool of instructors

UNIANOVA score BY city instructor
/METHOD = SSTYPE(3)
/INTERCEPT = INCLUDE
/CRITERIA = ALPHA(.05)
/RANDOM=instructor
/DESIGN = city instructor(city).

nested.sav - SPSS Data Editor

File Edit View Data Transform Analyze Graphs Utili

1 : Score 25

	Score	instructor	city
1	25	1	Atlanta
2	29	1	Atlanta
3	14	2	Atlanta
4	11	2	Atlanta
5	11	3	Chicago
6	6	3	Chicago
7	22	4	Chicago
8	18	4	Chicago
9	17	5	San Francisco
10	20	5	San Francisco
11	5	6	San Francisco
12	2	6	San Francisco

Slide 32 Instructors as random factors

NOTES:

If instructors treated as a random factor, there is no effect of city

Tests of Between-Subjects Effects

Dependent Variable: Score

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	**2700.000**	**1**	**2700.000**	**14.273**	**.032**
	Error	**567.500**	**3**	**189.167**[a]		
city	**Hypothesis**	**156.500**	**2**	**78.250**	**.414**	**.694**
	Error	**567.500**	**3**	**189.167**[a]		
instructor(city)	Hypothesis	**567.500**	**3**	189.167	27.024	.001
	Error	42.000	6	7.000[b]		

a. MS(instructor(city))

b. MS(Error)

Business implication: transfer or train the instructors rather than close down an inferior city's airport repair facility

Slide 33 If instructors treated as a random factor, there is no effect of city

NOTES:

Repeated Measures ANOVA

Chapter 16

If the responses are from repeated measurements of the same individual (plot, beaker, animal), the observations can not be treated as if they are independent. Observations from the same individual are often positively correlated. A repeated measures analysis must be used. It is usually advantageous to do so, because more powerful tests of hypotheses are possible.

Slide 34 Repeated Measures ANOVA

NOTES:

Repeated measures designs

Sampling units serve as their own controls

- Observations are collected at different times on the same sampling unit
  - Placebo, control drug trials
  - Sampling the same quadrat (area) through time
  - The errors within a subject are correlated
- Within and between subject factors
  - Within subject factors: two different observations of the same sampling unit (*e.g.,* time or drug dose)
  - Between subject factors: disjunct groups of sampling units (patients, plots, treatment, order of treatment)
- Repeated measures designs offer much more powerful tests than non-repeated designs

Slide 35 Repeated measures designs

NOTES:

Advantages & Disadvantages

From Neter et al. (1996)

- Advantages
  - Increased precision because between-subject variability is excluded from experimental error
  - Economizes on subjects
  - When the shape of the time effect is important, measures of the same subject (fitting population growth is possible)
- Disadvantages & Interferences
  - Order effect
  - Carryover effect (bland soup, good soup; grocery shopping [full & empty trips])
- Other disadvantages: more complicated assumptions and models

Slide 36 Advantages & Disadvantages

NOTES:

Analyzing repeated measures designs

Three classes of repeated measures analysis

- Repeated measures designs
  - Common features
    - Repeated measures from the same individual, bottle or area
    - Correlated observations
      - Between-individual heterogeneity
      - Correlations within individuals
      - Measurement error
  - 1) Univariate repeated measures (Winer et al.)
    - Developed by Fisher, individuals as a random effect
    - Assumes Sphericity
    - Equivalent to a split-plot design with subjects as a fixed factor
  - 2) Multivariate Repeated Measures (Profile analysis)
    - Hotelling's T^2 and other multivariate statistics
    - Scheiner 2001 on MANOVA & von Ende (2001) on repeated measures
  - 3) Longitudinal models
    - Singer & Willett multilevel longitudinal models
    - Multilevel Longitudinal models (Singer & Willett 2003, Fitzmaurice et al. 2004)
      - More detailed anaysis of within-individual trajectories and error structure
    - Allows autocorrelated errors in assessing time effects
    - SAS Proc mixed, SPSS Mixed
- If there are just two paired variables, use a paired *t* test
- Nonparametric test: Friedman's ANOVA

Slide 37 Analyzing repeated measures designs

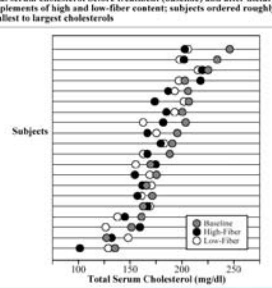
NOTES:

Case study 16.2

- 20 subjects
- Randomized, double blind, crossover trial
- 1-wk baseline on normal diet
- Randomly assigned to High and low fiber diets
- 6 weeks on blood chemistry
- Normal diet for 2 weeks
- Crossed over to other diet.

Display 16.2

Total serum cholesterol before treatment (baseline) and after dietary supplements of high and low-fiber content; subjects ordered roughly from smallest to largest cholesterols



Slide 38 Case study 16.2

NOTES:

SPSS Syntax for cholesterol

GLM multivariate (=MANOVA) in SPSS advanced modules

```
* Compare to Display 1610 in text.
GLM
baseline hifibr lofibr
/WSFACTOR = diet 3 Difference
/METHOD = SSTYPE(3)
/PLOT = PROFILE( diet )
/EMMEANS = TABLES(diet)
/PRINT = DESCRIPTIVE
/CRITERIA = ALPHA(.05)
/WSDESIGN = diet .
```

The assumption for the multivariate approach is that the vector of the response variables follow a multivariate normal distribution, and the variance-covariance matrices are equal across the cells formed by the between-subjects effects.

Slide 39 SPSS Syntax for cholesterol

NOTES:

Large differences in diet effects on cholesterol

No reason to reject the sphericity assumption

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
diet	Sphericity Assumed	**2410.300**	2	1205.150	9.775	3.759E-004
	Greenhouse-Geisser	2410.300	1.999	1205.714	9.775	3.768E-004
	Huynh-Feldt	**2410.300**	**2.000**	**1205.150**	**9.775**	**3.759E-004**
	Lower-bound	2410.300	1.000	2410.300	9.775	5.557E-003
Error(diet)	Sphericity Assumed	4685.033	38	123.290		
	Greenhouse-Geisser	4685.033	37.982	123.348		
	Huynh-Feldt	4685.033	38.000	123.290		
	Lower-bound	4685.033	19.000	246.581		

Report that, ‘ univariate repeated measures ANOVA’ found strong evidence for diet effects on cholesterol (p=0.0004)’

Slide 40 Large differences in diet effects on cholesterol

NOTES:

Effect of high fiber diet

Little difference between High and Low-fiber diet
Note Bonferroni CI’s narrower than the [-8.8 10.1] CI’s using the T^2 multiplier (Display 16.10)

Pairwise Comparisons

Measure: MEASURE_1

(I) diet	(J) diet	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	13.850*	3.533	.003	4.576	23.124
	3	13.000*	3.473	.004	3.882	22.118
2	1	-13.850*	3.533	.003	-23.124	-4.576
	3	-.850	3.528	1.000	-10.110	8.410
3	1	-13.000*	3.473	.004	-22.118	-3.882
	2	.850	3.528	1.000	-8.410	10.110

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

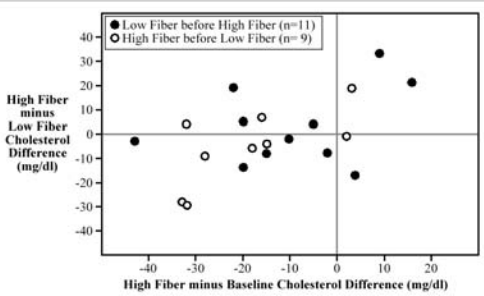
a. Adjustment for multiple comparisons: Bonferroni.

Slide 41 Effect of high fiber diet

NOTES:

Display 16.11

High-baseline and high-low cholesterol levels, by the order of assignment



Slide 42

NOTES:

Test for an order effect

Order is a between-subjects factor, diet is within subjects

```
* Repeated measures between subjects test.
GLM
baseline hifibr lofibr BY order
/WSFACTOR = diet 3 Difference
/CONTRAST (order)=Difference
/METHOD = SSTYPE(3)
/PLOT = PROFILE( diet order*diet )
/CRITERIA = ALPHA(.05)
/WSDESIGN = diet
/DESIGN = order .
```

Slide 43 Test for an order effect

NOTES:

No order effect on diet

Sphericity assumption appears justified here.

Measure: MEASURE_1 — Tests of Within-Subjects Effects

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
diet	Sphericity Assumed	2410.300	2	1205.150	10.017	.00035
	Greenhouse-Geisser	2410.300	1.993	1209.302	10.017	.00035
	Huynh-Feldt	2410.300	2.000	1205.150	10.017	.00035
	Lower-bound	2410.300	1.000	2410.300	10.017	.00536
diet * order	Sphericity Assumed	354.033	2	177.017	1.471	.243
	Greenhouse-Geisser	354.033	1.993	177.626	1.471	.243
	Huynh-Feldt	354.033	2.000	177.017	1.471	.243
	Lower-bound	354.033	1.000	354.033	1.471	.241
Error(diet)	Sphericity Assumed	4331.000	36	120.306		
	Greenhouse-Geisser	4331.000	35.876	120.720		
	Huynh-Feldt	4331.000	36.000	120.306		
	Lower-bound	4331.000	18.000	240.611		

There is little evidence (repeated measures ANOVA diet*order effect, p=0.24) that diet order affects cholesterol differences among diets

Slide 44 No order effect on diet

NOTES:

Friedman's Nonparametric repeated measures ANOVA

Example from Hollander & Wolfe

FIGURE 7.1. Three methods of rounding first base: ◊ path = round out method, • path = narrow angle method, solid path = wide angle method.

Slide 45 Friedman's Nonparametric repeated measures ANOVA

NOTES:

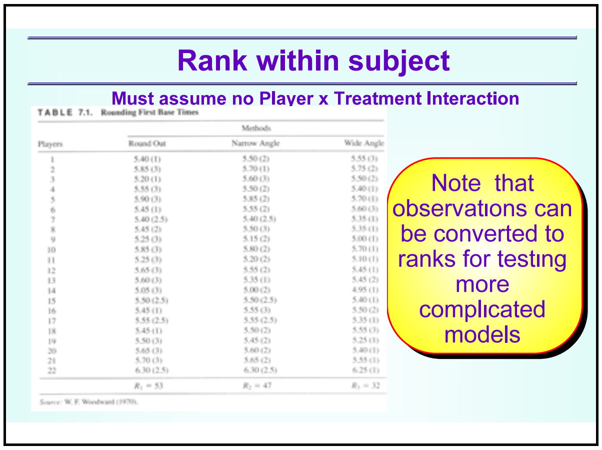


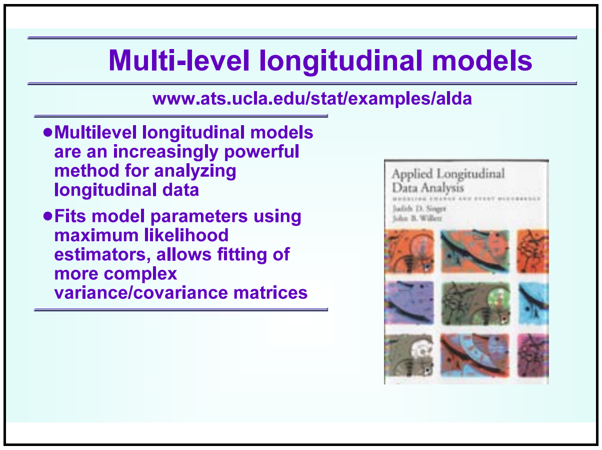
TABLE 7.1. Rounding First Base Times

Players	Methods: Round Out	Narrow Angle	Wide Angle
1	5.40 (1)	5.50 (2)	5.55 (3)
2	5.85 (3)	5.70 (1)	5.75 (2)
3	5.20 (1)	5.60 (3)	5.50 (2)
4	5.55 (3)	5.50 (2)	5.40 (1)
5	5.90 (3)	5.85 (2)	5.70 (1)
6	5.45 (1)	5.55 (2)	5.60 (3)
7	5.40 (2.5)	5.40 (2.5)	5.35 (1)
8	5.45 (2)	5.50 (3)	5.35 (1)
9	5.25 (3)	5.15 (2)	5.00 (1)
10	5.85 (3)	5.80 (2)	5.70 (1)
11	5.25 (3)	5.20 (2)	5.10 (1)
12	5.65 (3)	5.55 (2)	5.45 (1)
13	5.60 (3)	5.35 (1)	5.45 (2)
14	5.05 (3)	5.00 (2)	4.95 (1)
15	5.50 (2.5)	5.50 (2.5)	5.40 (1)
16	5.45 (1)	5.55 (3)	5.50 (2)
17	5.55 (2.5)	5.55 (2.5)	5.35 (1)
18	5.45 (1)	5.50 (2)	5.55 (3)
19	5.50 (3)	5.45 (2)	5.25 (1)
20	5.65 (3)	5.60 (2)	5.40 (1)
21	5.70 (3)	5.65 (2)	5.55 (1)
22	6.30 (2.5)	6.30 (2.5)	6.25 (1)
	$R_1 = 53$	$R_2 = 47$	$R_3 = 32$

Source: W. F. Woodward (1970).

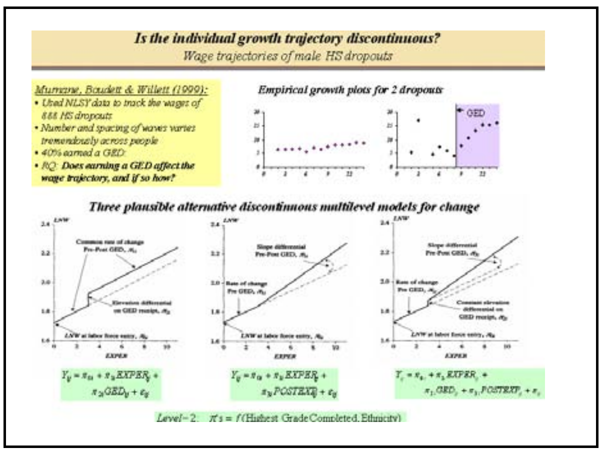
Slide 46 Rank within subject

NOTES:



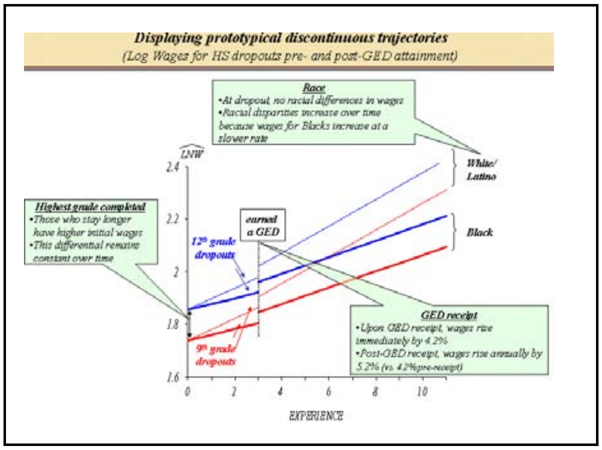
Slide 47 Multi-level longitudinal models

NOTES:



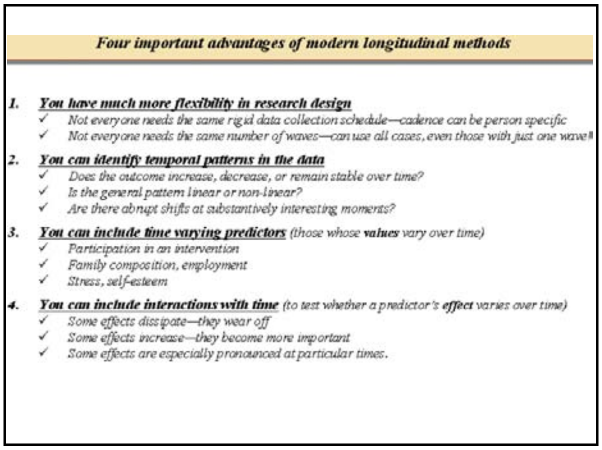
Slide 48

NOTES:



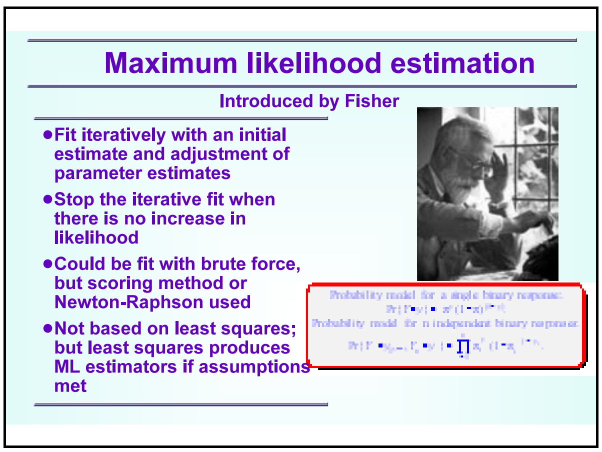
Slide 49

NOTES:



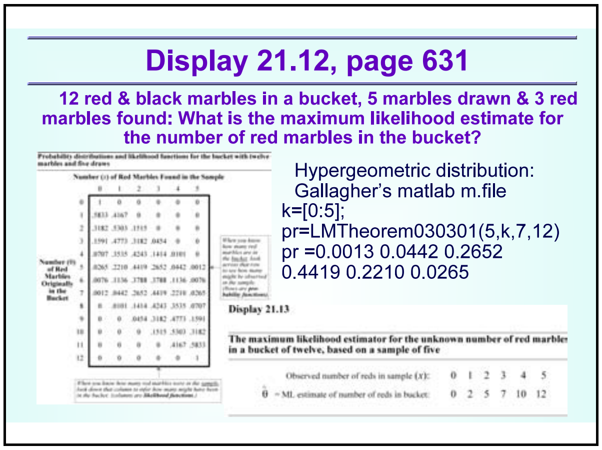
Slide 50

NOTES:



Slide 51 Maximum likelihood estimation

NOTES:



Slide 52 Display 21.12, page 631

NOTES: