2.2. PLANNED COMPARISONS

PLANNED COMPARISONS

- Researchers often have a good idea before they even collect data where the difference between the means should be.
- So, using planned comparisons, they can by-pass the ANOVA.
- Arguably, unplanned comparisons (ANOVA) are useful when we don't have any idea where the differences might be.
- Planned comparisons are **hypothesis driven**. Theories or past research guide you in specifying the nature of the contrast.
- They are **planned a priori**. You must decide the nature of the contrast(s) you want to test before you collect data.
- Some experts believe planned comparisons are useful. But it is unjustifiable to think that familywise error rate does not increase. Others (eg. Keppel) believe they should be treated very differently - the familywise error rate does not increase.

PLANNED COMPARISONS AS CONTRASTS

- We conduct planed comparisons by performing contrasts.
- **Contrasts** are specified by giving the means in the analysis weights. The **weights** can technically take on any value, positive or negative. The pattern of the weights need to **reflect the hypothesis** you want to test.

THE SIMPLEST CONTRAST: T-TEST

$$\psi = [(+1)(\bar{X}_1)] + [(-1)(\bar{X}_2)]$$

Expect mean 1 to be larger than mean 2

$$\psi = [(-1)(\bar{X}_1)] + [(+1)(\bar{X}_2)]$$

Expect mean 1 to be smaller than mean 2

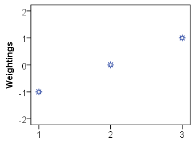
- In both cases above, when the null hypothesis is true, the solution to the above contrasts **results in a value that is zero** (within sampling fluctuations).

CHOOSING CONTRASTS

- There are several rules that govern the generation of planned contrasts:
  I. Weight each mean of interest in accordance to how we expect the means to differ.
  II. Weightings must sum to zero.
  III. Weightings must reflect the expected pattern in the means (based on hypothesis).

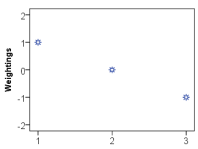
LINEAR CONTRAST

- Contrasts are often used usefully in the context of testing linear effects across 3 or more means.



$$\psi = [(-1)(\bar{X}_1)] + [(0)(\bar{X}_2)] + [(+1)(\bar{X}_3)]$$

specifying an upward linear trend



$$\psi = [(+1)(\bar{X}_1)] + [(0)(\bar{X}_2)] + [(-1)(\bar{X}_3)]$$

specifying a downward linear trend

- When testing a linear contrast with 4 means, each mean participates in the analysis.

KEPPEL'S k-1 RULE

- Keppel (1991) proposed an alternative method for controlling familywise error rates in the context of planned comparisons.
- He proposed that we should be allowed to do **k -1 comparisons without having to adjust the per comparison error rate**.
  - k = number of means in the analysis.
- For example, if you had a case where there were four means included in the analysis, you would be allowed to do 3 planned comparisons with per contrast alpha set at .05 (no correction necessary).
- However, if you decided to exceed the allowable k – 1 planned comparisons, your comparisons, as a family, now run the risk of resulting in a Type I error rate that exceeds the per contrast error rate of .05.
- Therefore, you need to calculate an adjusted per contrast error rate for all of the comparisons in this case (modified Bonferonni method).

PAIRWISE AND NON-PAIRWISE

- **Pairwise comparison:** involves information from two means.

$$\psi = [(+1)(\bar{X}_1)] + [(-1)(\bar{X}_2)]$$

- **Non-pairwise comparison:** involves information from three or more means (collapses means into each other by combining 2 or more means together).

$$\psi = [(.5)(\bar{X}_1)] + [(.5)(\bar{X}_2)] + [(-1)(\bar{X}_3)]$$

- ANOVA tests for both pairwise and non-pairwise comparisons. Occasionally, people do an ANOVA, get a significant effect, do some follow-up multiple comparisons and do not find any statistically significant results. It's usually because they did not test any non-pairwise comparisons.

OTHER CONTRASTS: NON-LINEAR

- A **nonlinear contrast** implies that the trend of the means are not increasing or decreasing in a monotonic fashion.
- The most common nonlinear contrast is a **quadratic function** - the contrast has one "bend" in the trend of the weightings.

V Shaped Quadratic Function

$$\psi = [(+1)(\bar{X}_1)] + [(-2)(\bar{X}_2)] + [(+1)(\bar{X}_3)]$$

Mean 2 is hypothesised to be lower than Mean 1 and Mean 3

Inverted V Shaped Quadratic Function

$$\psi = [(-1)(\bar{X}_1)] + [(+2)(\bar{X}_2)] + [(-1)(\bar{X}_3)]$$

Mean 2 is hypothesised to be higher than Mean 1 and Mean 3

Lab 1: Introduction to SPSS

① *Naming Variables*

- "Variable view" tab at bottom ⟶ change variable "name", "decimal", "label" (longer names), or "value labels" if the numbers mean something else (eg. 2 indicates females).

② *Descriptive Statistics*

- Analyse ⟶ descriptive stats ⟶ frequencies ⟶ add variables ⟶ stats ⟶ select boxes (mean, median, std dev, skewness, kurtosis, and variances).

③ *Histogram*

- Analyse ⟶ descriptive stats ⟶ frequencies ⟶ charts ⟶ histograms (deselect stats if seen).
  - Double click to open chart editor.

④ *Pearson Correlation*

- Analyse ⟶ **correlate** ⟶ **bivariate** ⟶ add both variables ⟶ select "Pearson" in correlation coefficients.
- Calculator: square correlation = coefficient of determination.

⑤ *Grouping Data*

- Data ⟶ split file ⟶ select "compare groups" ⟶ add variable to "groups based on".
- 3 separate histograms into same scale/figure (to compare):
  - Data ⟶ split file ⟶ select "analyse all cases".
  - Graphs ⟶ legacy dialogs ⟶ histogram ⟶ put "non-split" groups in "variables" + "split group" in rows.

⑥ *One-way Between Subjects ANOVA (3 groups)*

- Used to test hypothesis that **3 or more means between groups** are equal simultaneously. Represented on a bar graph. Effect size measured by eta squared.
- Analyse ⟶ **compare means** ⟶ **one-way ANOVA** ⟶ add variables. Options ⟶ select descriptive, HOV.
- Deciding on the Post Hoc test:
  - p>.05 = assumes equal variances (use Fishers LSD).
  - p<.05 = assumes unequal variances (use Brown Forsythe).

Lab 2: Planned Comparisons

- Attractive approach when a **particular pattern of differences between 2 or more means** is expected. Hypothesis driven and are planned a priori.
  - Pairwise comparison: involves the inclusion of 2 means.
  - Non-pairwise comparison: involves the inclusion of 3 or more means (can collapse 2 means into 1).

① *Games-Howell (single-step)*

- Analyze ⟶ compare means ⟶ one-way ANOVA. Post Hoc ⟶ Games-Howell.
- Data ⟶ split file ⟶ select "compare means" ⟶ add to groups based on. Analyze ⟶ select descriptive stats, skewness, and kurtosis.
- Bootstrap: deselect split file. Analyze ⟶ compare means ⟶ one-way ANOVA. Bootstrap ⟶ select "perform bootstrapping" ⟶ select bias correct accelerated (BCa).

② *Contrast Analysis*

- Analyze ⟶ **compare means** ⟶ **one-way ANOVA**. **Contrasts** ⟶ **specify coefficients** that you expect the means to be.
  - Linear: 1, 0, -1 ⟶ add after each.
  - Non-pairwise comparison: 0.5, 0.5, 1 ⟶ add after each.
  - Non-linear (quadratic): -1, 1, 1, -1 ⟶ add after each.
- Options ⟶ descriptive stats.
- Graphs ⟶ error bars ⟶ simple ⟶ variables.
- Could test the hypothesis of difference between the means using multiple comparisons procedure - Fishers LSD.
  - Remove contrasts. Post Hoc ⟶ select LSD.
  - Nothing will be significant.

Lab 3: One-Way Within-Subjects ANOVA

- Used to test the hypothesis that **3 or more dependent means are equal simultaneously**. Represented on a line graph. Effect size measured by partial eta squared.
- Assumption of sphericity: implies the standard error of the difference between the means across all comparisons is going to be equal within sampling fluctuations. Only relevant in designs with >2 levels.
- If Mauchly's test is not statistically significant (p>.05), sphericity has been satisfied. When sphericity is violated (p<.05), use **Huynh-Feldt** results. If sample size is <10 in each group, use **Greenhouse-Geisser adjustment**.

① *One-Way Within-Subjects ANOVA (3 means)*

- Analyze ⟶ **general linear model** ⟶ **repeated measures** ⟶ factor name (IV) ⟶ number of levels = 3 ⟶ define ⟶ add specific values to each group. Options ⟶ select descriptive stats and estimated effect size. Do not need to click a button for sphericity, automatic in SPSS.
- Multiple comparisons: options ⟶ put variable (IV) in "display main effects" ⟶ select "compare main effects" ⟶ confidence interval adjustment should be LSD.
- Plots ⟶ IV on horizontal axis (line graph) ⟶ add.

② *Sphericity Violated (3 means)*

- Analyze ⟶ general linear model ⟶ repeated measures ⟶ change factor and define groups. Options ⟶ select display statistics, estimates of effect size and compare mean effect ⟶ LSD (use Huynh-Feldt is sphericity is violated - ie. Mauchly's test is significant).

③ *>4 Means - Bonferroni (single-step)*

- Analyze ⟶ general linear model ⟶ repeated measures ⟶ factor name and number of levels ⟶ define. Options ⟶ select descriptive stats, compare main effects ⟶ Bonferroni.

④ *Trend Analysis (does not assume ANOVA first)*

- **Trend analysis:** tests hypothesis that the differences between the means follow a particular pattern (usually linear/quadratic).
  - Effect size: '$r_{alerting}$' (correlation between contrast weightings and observed means).
- Analyze ⟶ **general linear model** ⟶ **repeated measures** ⟶ number of levels ⟶ define. Options ⟶ select descriptive stats and compare means ⟶ select Bonferroni.
- **Check "test of within subjects contrasts"** table and check the plotted graph - are the effects linear or quadratic?