

MANOVA

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CPSY501
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Please download:

- *chicken.sav*
- *Range et al. paper*

Outline for today: MANOVA

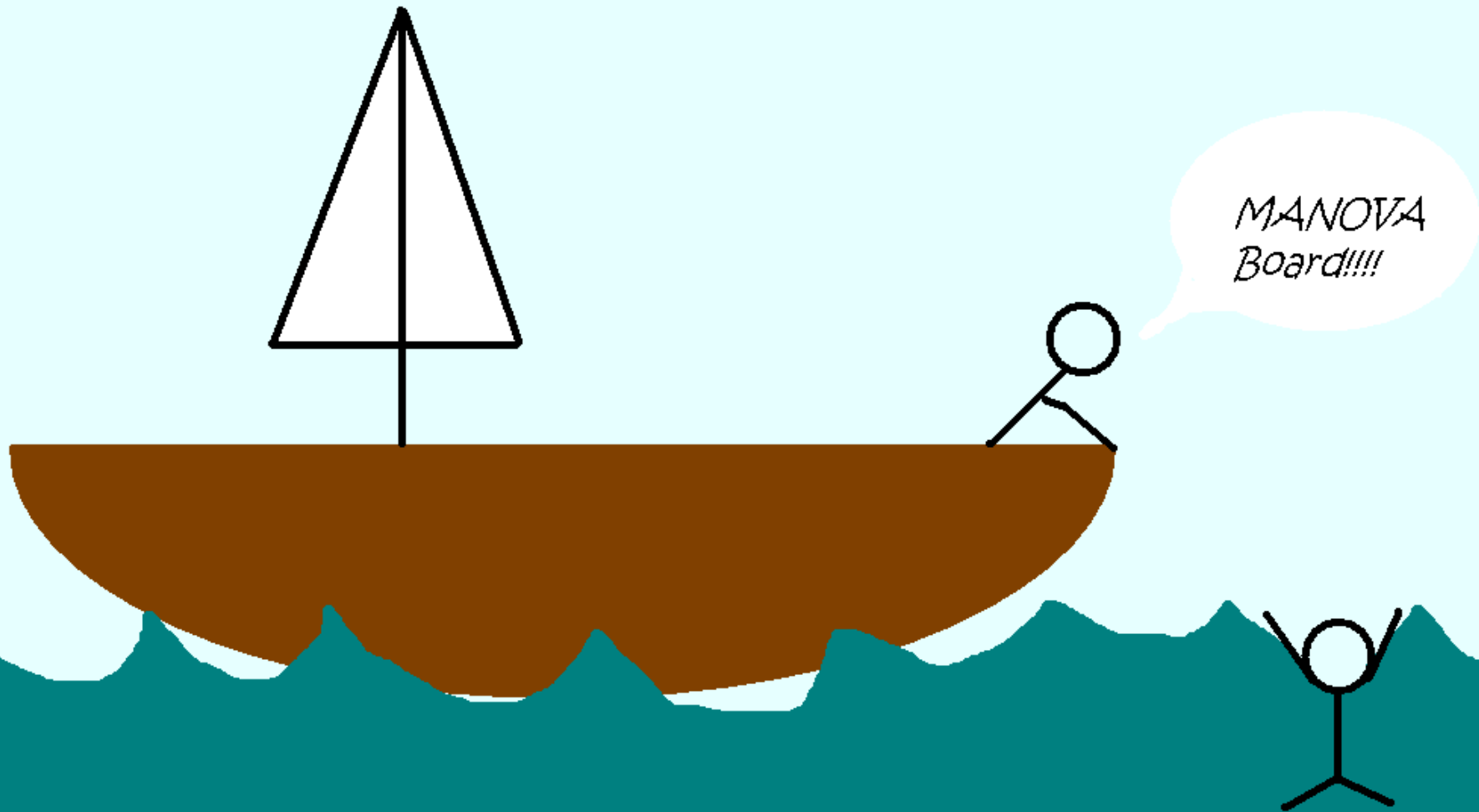
■ MANOVA: Concepts

- Assumptions: multivariate normality
- Assumptions: variance–covariance matrices
- Running it in SPSS: chicken.sav example
- Interpreting output

■ MANOVA journal article: Range, et al. (2000)

- Study design: particip., process, measures
- Results and conclusions

■ Further reading: Factor Analysis



MANOVA: Multiple DVs

- Theory developed by Wilks in 1932
 - But not practically computable until recently
- ANOVA with multiple (possibly correlated) DVs
- DVs should be theoretically related
 - e.g., subscales of one measure:
Beck Depression Inventory (BDI-II) has affective and physiological subscales
 - e.g., two measures of same outcome: BDI (self-rated) and Hamilton (clinician-rated)
- DVs should be correlated but not collinear

Hotelling's T^2 and MANOVA

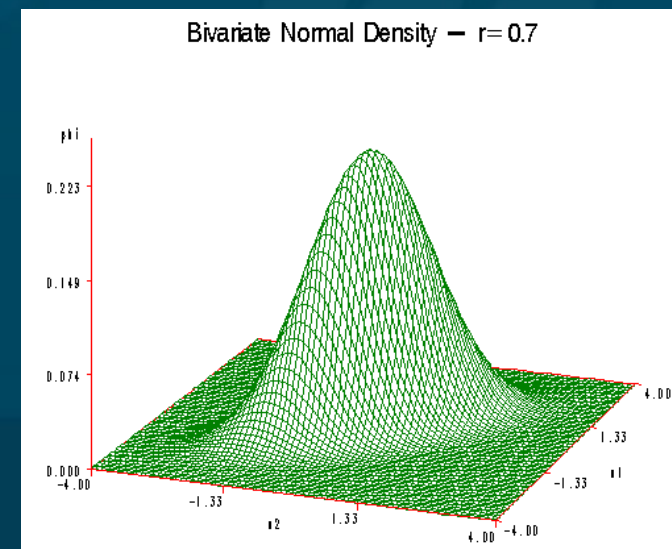
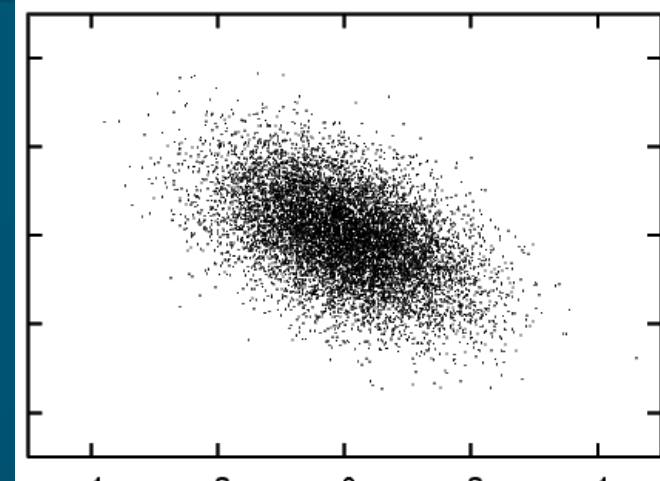
- ANOVA with just 2 groups is the t -test
- MANOVA with just 2 groups is Hotelling's T^2 :
 - 1 dichotomous IV; several continuous DVs
 - Null hypothesis: both groups score the same on all the DVs
- General MANOVA compares several groups
 - Omnibus: do the groups differ on the DVs?
 - Follow-up: post-hoc (for several categories)
 - Follow-up: univariate ANOVA (single DV)
 - Follow-up: simple effects (for interactions)

MANOVA: Assumptions

- Same as ANOVA: **parametricity**
 - But now **multi**-dimensional!
- DVs all **scale**-level
- All observations are **independent**
- Normality → **Multi-normality**
- Homogeneity of variances → homogeneity of **variance-covariance** matrices
- **Sample size**: need **min cell count** > **#DVs**
 - If min cell count ≥ 30 , then it is **robust** to non-normality and variances

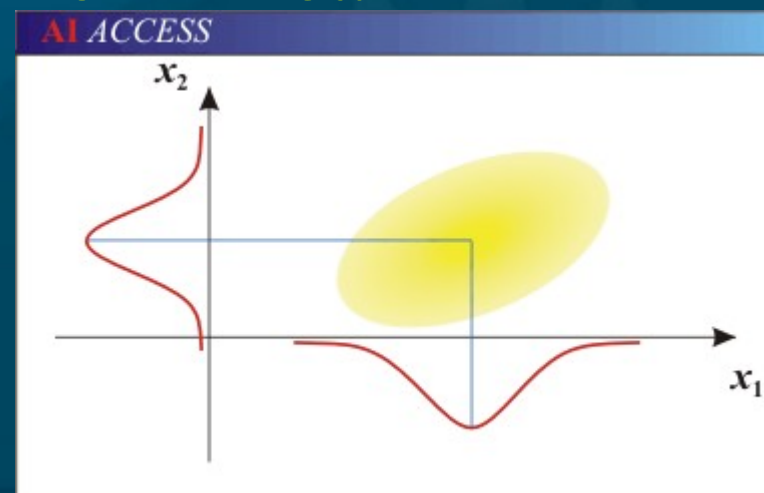
Multivariate Normality

- A set of DVs are **multi-variate normally** distributed if every linear combination of the DVs is normally distributed
- The DVs may be **correlated** (tilted ellipse)
- The **mean** of the distribution is a **vector**
- The **variance** is described by a symmetric matrix: the **variance-covariance matrix**
 - **Diagonal** entries are the variances of individual DVs



Checking Multi-Normality

- Check that each DV is **normal** (univariate)
 - Technically, we should check this **per-cell**, but most articles just combine all groups
 - If all **cell counts ≥ 20** , multi-normality is roughly met (by Central Limit Theorem)
- Check that the DVs do not have **non-linear** relationships to each other
 - Examine scatterplots of all **pairs** of DVs (**matrix scatter**)
 - Watch for any **curvilinear** structure

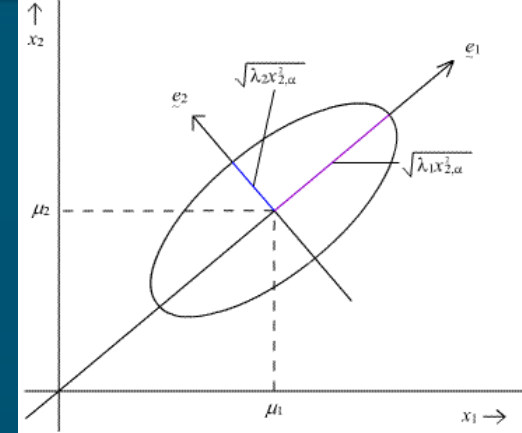


Multi-Normality & Collinearity

- Also check the **correlations** amongst all DVs:
- If too **low**, then the DVs are **not related**:
 - We won't gain anything by doing MANOVA instead of **separate ANOVAs** on each DV
- If too **high** ($|r| > 0.8$ or so), risk of **collinearity**: two DVs that give the **same** info
 - We don't gain anything by adding the DV, only **lose power**:
 - Should **remove** that DV or **combine** them
 - SPSS will **abort** if it detects collinearity of DV

Variance–Covariance

- The Variance–Covariance matrix describes **multidimensional spread** of the DVs
 - Different **multi-normal** distribution of DVs in each **cell** of the factorial model
 - MANOVA looks for **differences** in the **means** of those multi-normals
- MANOVA assumes the **variance–covariance** matrices of those multi-normals are **equal** across all cells
 - This is the multi-dimensional equivalent of **homogeneity of variance**



Checking Variance–Covariance

- Homogeneity of variance–covariance matrices:
- First, if all cell sizes are roughly equal, skip this test and just use Pillai's trace (see output)
- Next, if all cell sizes are ≥ 30 , we are reasonably robust to violations of this assum.
- Next, ensure we have multi–normality
- Then run Levene's test on each DV (univariate)
- Lastly, run Box's Test: we want insignificance
 - Box's Test is not reliable if we don't have multi–normality

MANOVA: Chicken example

- Example **dataset**: chicken.sav (from Field)
- **IV**: **Group** (Manic Psychosis vs. Sussex Lecturer)
- **DV**: **Quality** of chicken impers. (score out of 10)
- **DV**: **Quantity** of chicken impers. per day
- **RQ**: Do **manic psychotics** show a difference from **Sussex lecturers** in **quality+quantity** of chicken impersonations?
- Analysis: One-way **MANOVA**
 - Only two groups: equivalent to **Hotelling's T^2**

Chickens: Check Multi-Normality

- **Univariate** normality by group: Explore:
 - Dependents: DVs; Factors: IVs
 - Display: Plots
 - Plots: Histogram, Normality plots with tests
 - ◆ Result: Lecturers non-normal on Quality ($p=.021$)
- Check **linearity**: Graphs → Legacy → Scatter:
 - Simple Scatter (or Matrix if >2 DVs)
- Check **correlation**: An. → Correlate → Bivariate:
 - ◆ Result: 0.788 (almost worry about collinearity)

MANOVA: SPSS (Chickens)

- Analyze → GLM → Multivariate:
 - Dependent Variables: Quality, Quantity
 - Fixed Factor(s): Group
 - Options:
Descriptives, Effect Size, Homogeneity
- Other buttons for Model, Plots, Planned Contrasts, Post-Hoc (multiple comparisons), Save (residuals, etc.) are as in regular ANOVA/Regression

Output: Check Variance/Covar

- Cell sizes are roughly equal: can use Pillai's tr
- Cell sizes not > 30
- Not so sure about multi-normality
- Levene's Test (univariate):
 - inhomogeneity of variance on Quality
- Box's Test (covar matrices):
 - Inhomogeneity of variance-covariance matrices
- But we are okay because of balanced design

MANOVA: Output

■ Multivariate Tests:

- Wilks' Lambda (most commonly used)
- Pillai's Trace (robust to inhomogeneity of variance, as long as cells are balanced)
- Roy's Largest Root (too optimistic)
 - ◆ (see Tabachnick & Fidell, 2007)

■ Tests of Between-Subjects Effects

- Use a Bonferroni adjustment

■ Effect size Partial η^2 : proportion of variance in DV

MANOVA: Follow-Up

- Remember MANOVA is **omnibus**: need follow-up
 - Try **univariate** ANOVAs: **which DVs** show differences?
(Possibly none show diffs **individually**, only when taken **together**!)
 - Try **post-hoc** multiple comparisons: if an IV has several groups, **which groups** differ?
 - Try **simple effects**: if there is a significant interaction of multiple IVs, try to understand it by **fixing** one of the Ivs
- Try **plots**: Scatter → Panel by: **IVs**

MANOVA: Further Reading

- Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998).
Multivariate data analysis (5th ed.).
New York: Macmillan.
- Weinfurt, K. P. (1995).
Multivariate analysis of variance.
In L. G. Grimm & P. R. Yarnold (Ed.),
Reading and understanding multivariate statistics
(pp. 245–276).
Washington, DC: APA. [QA278.R43 1995]

MANOVA Article: Range et al.

- Range, L. M., Kovac, S. H., & Marion, M. S. (2000). Does writing about the bereavement lessen grief following sudden, unintentional death? *Death Studies*, 24, 115–134.
- Writing about traumatic events produces improvement even after intervention ends:
 - physical health, psychological functioning
- Need more systematic research to assess with specific populations
- Writing about events/emotions surrounding death of a loved one by sudden, unintentional

Range: Participants

- N = 64 undergraduate students
 - (20 did not complete...)
- Bereaved within the past 2.5 years:
 - due to an accident or homicide,
 - mildly to extremely close to the deceased,
 - and upset by the death
- Experimental design: random assignment to 2 different writing conditions:
 - Profound
 - Trivial (control condition)

Range: Therapy Procedure

- Pre-test measures: depression, anxiety, grief, impact, and non-routine health visits
- Wrote 15 min per day for 4 days on either
 - profound (on death of loved one) OR
 - trivial (unrelated topic) topics
- Post-test with same measures
- Follow-up after 6 weeks
- IVs? Between-subjects? Within-subjects?

Range: Measures (DVs) (p.120)

- Self-rating Depression Scale (SDS)
- Impact of Event Scale (IES)
- Grief Recovery Questions (GRQ)
- Grief Experience Questionnaire (GEQ)
- Multiple Affect Adjective Checklist-Revised (MAACL-R)
 - 5 subscales grouped into 2 summary scales:
 - Dysphoria: Anxiety, Depr, Hostility
 - PASS: Positive Affect, Sensation Seeking

Range: Research Question

- RQ: Does **writing** about the accidental or homicidal deaths of loved ones **improve** bereavement **recovery** in the areas of **physical** and **psychological** functioning?
- Hypotheses – The **profound** condition will show:
 - More **negative emotions** and mood at **post**–testing than **trivial** condition
 - More **positive mood**, more bereavement **recovery**, and fewer health centre **visits** at **follow-up** than **trivial** condition

Why not multiple ANOVAs?

- Separate 2 (Condition: Profound/Trivial) x 3 (Time: Pre/Post/Follow) ANOVA for each DV?

Groups	$F(2,38)$	p	Time Difference
Anxiety	5.35	0.009	Pre > F
Depression	4.66	0.016	Pre > F

- If Anxiety and Depression had a correlation of $r = .80$, how would we interpret the ANOVAs?

Why MANOVA?

- Controlling against **Type I** error
- **Multivariate** analysis of effects
 - If outcome measures (DV) are **correlated**,
 - they may be partially **redundant**:
- MANOVA takes these correlations into account, **removing** redundancy
 - Dependent variables treated as a whole **system** rather than as separate variables

Range: Research Design

- 2x3 (Condition x Time) mixed-design MANOVA
- DVs: SDS (depr), IES (impact), GRQ (recovery), GEQ (exp), and MAACL-R (affect adjectives)

	Pre-Test					Post-Test					Follow-Up				
	S D S	I E S	G R Q	G E Q	M A A C L	S D S	I E S	G R Q	G E Q	M A A C L	S D S	I E S	G R Q	G E Q	M A A C L
Profound															
Trivial															

Range: Results

- Did not report **multivariate** statistic (**Wilks' Λ**)
- “**No** significant **interaction**”
- “**No** significant main effect for **condition**”
- “**Significant** main effect for **time**” (p.125)
 - $F(18, 22) = 4.80, p = .001$
- **Follow-up**: Separate 2 (**Condition**) x 3 (**Time**) ANOVAs for each **DV** (see Tables 3 & 4)
 - Focus on **Time** main effect in each one
 - **Post-hoc** (Tukey's HSD) to find which times differ (**Pre-** / **Post-** / **Follow-up**)

Range: Conclusions

- Original RQs: The **profound** condition will show:
 - More **negative emotions** and mood at **post**-testing than **trivial** condition
 - More **positive mood**, more bereavement **recovery**, and fewer health centre **visits** at **follow-up** than **trivial** condition
- Hypotheses **not** supported!
- Only conclusion: “**Time heals all wounds**”?

Factor Analysis

- Typically in Psych, can have **lots of IVs!**
 - Which are **important?**
 - Exclude non-useful IVs → increase **power**
- **Exploratory** factor analysis (**EFA**)
 - Explore the **interrelationships** among a given set of variables, w/o a-priori ideas
- **Confirmatory** factor analysis (**CFA**)
 - Confirm specific **hypotheses** or theories concerning the **structure** underlying a set of variables

Factor Analysis: References

- Kristopher J. Preacher & Robert C. MacCallum (2003).
Repairing Tom Swift's Electric Factor Analysis Machine.
Understanding Statistics, 2(1), 13–43.
- Anna B. Costello & Jason W. Osborne (2005).
Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis.
Practical Assessment Research & Evaluation, 10(7), 1–9.

FA References: Categorical

- Maraun, M. D., Slaney, K., & Jalava, J. (2005). Dual scaling for the analysis of categorical data. *Journal of Personality Assessment*, 85, 209–217.
 - This is an “introductory” discussion, for disseminating descriptions of this procedure to professionals