MANOVA

Please download:
- ***chicken.sav***

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CPSY501
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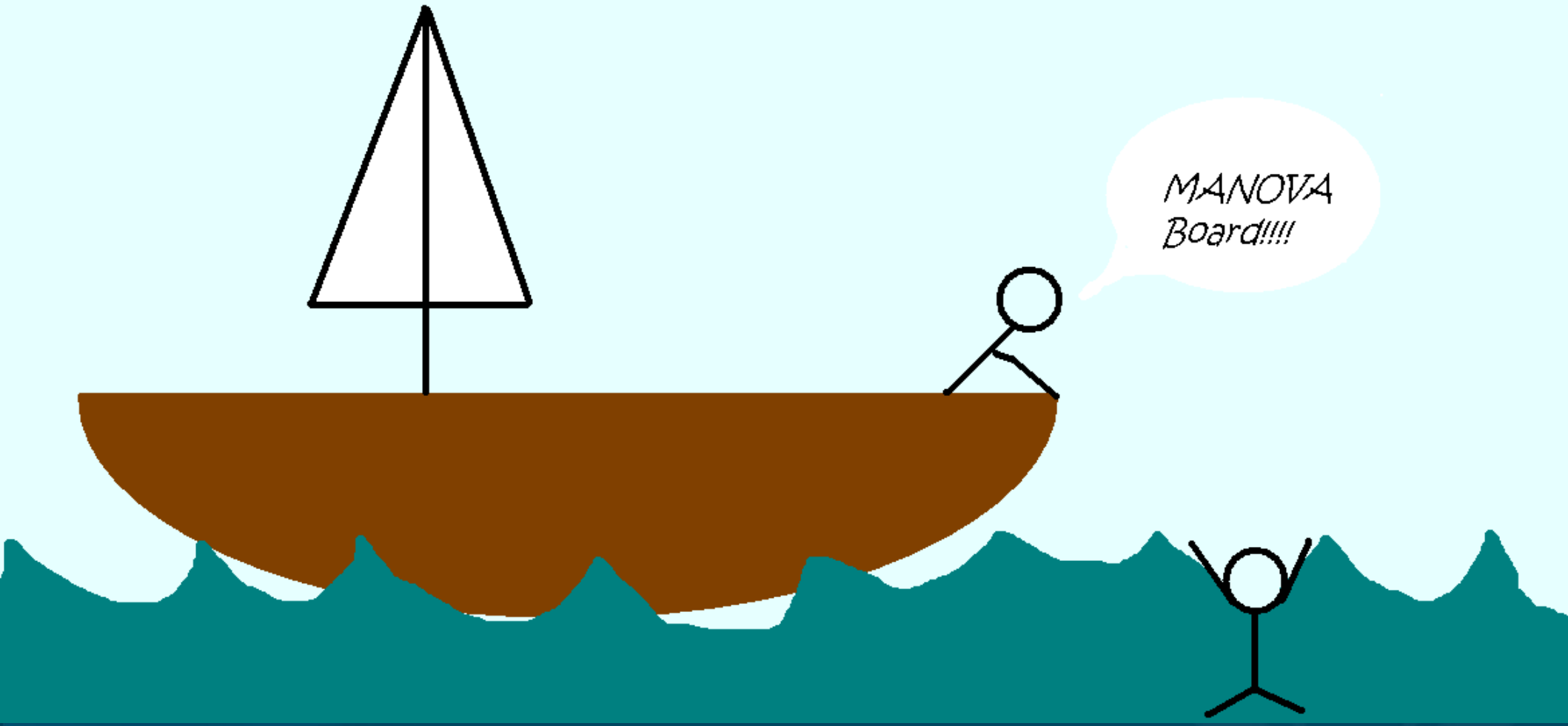
Outline for today: MANOVA

- 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



I think we all liked this one (-:

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

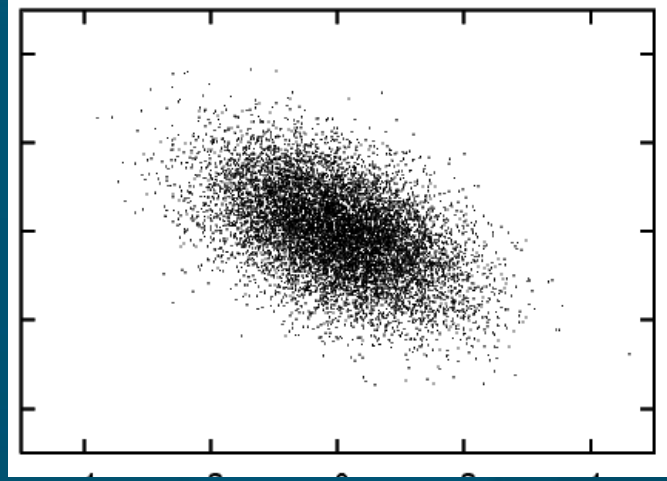
Hotelling's T^2 and MANOVA

- 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)

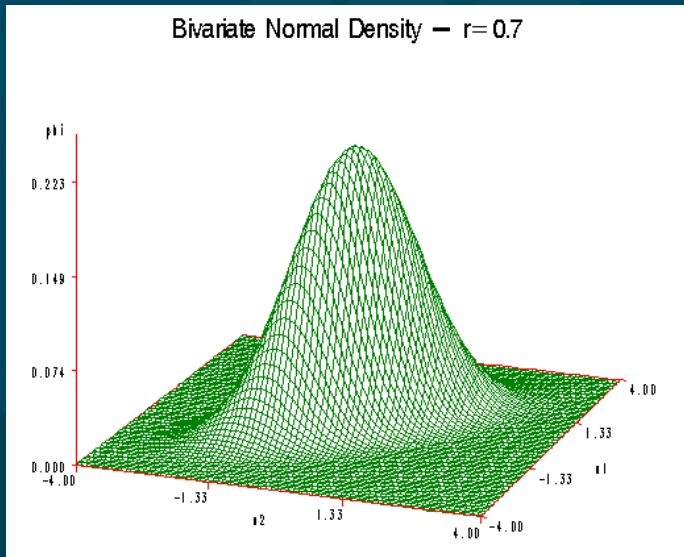
MANOVA: Assumptions

- 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

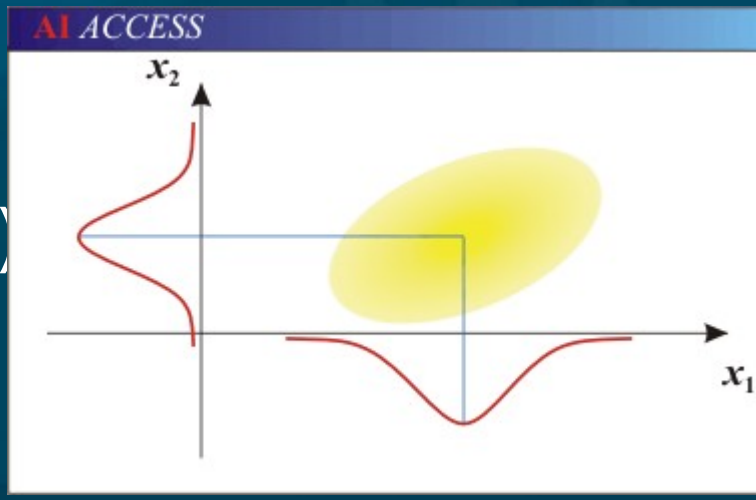


- A set of DVs are multi-variate normally distributed if every linear combination of the DVs is normally distrib
- The DVs may be correlated (tilted ellipse)
- The mean of the distribution is a vector
- The variance is described by a symmetric matrix: the variance-covariance matrix
  - Diagonal entries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



Checking Multi-Normality

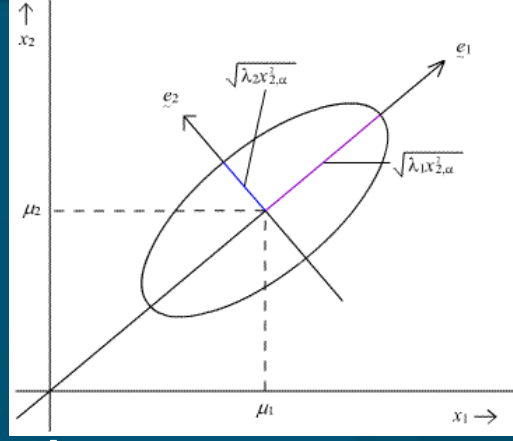
- Check that each DV is normal (univariate)
  - Technically, we should check this per-cell, but most articles just combine all groups
  - If all cell counts ≥ 20, multi-normality is roughly met (by Central Limit Theorem)
- Check that the DVs do not have non-linear relationships to each other
  - Examine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

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				
	SDS	IES	GRQ	GEQ	MAACL	SDS	IES	GRQ	GEQ	MAACL	SDS	IES	GRQ	GEQ	MAACL
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"?