Statistical Science Workshop 6-7 March 2025 University of Waikato – Tauranga
10-11 March University of Auckland – Leigh Marine Lab

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Session 2 Model execution and checking, interpreting results

In this workshop you will learn to

- Translate a research question into a statistical model
- Execute the model and apply the model-checking loop
- Calculate a measure of evidence for the research hypothesis (the likelihood ratio)
- Calculate a measure of uncertainty on the likelihood ratio (p-value / confidence limit))
- Report effect sizes with a measure of uncertainty
- Interpret parameter estimates in light of the research question

Goal of the first session Writing the statistical Model

Goal of the second session Executing a GLM in a statistical package
Using the model checking loop - - - - - - - >
Interpreting computer output
Interpreting the parameter estimates

> *..statistics must be relevant to making inferences in science and technology. The subject should be renamed statistical science and be focused on the experimental cycle, design-execute-analyse-predict.*
> *John Nelder 1999*

Statistical Science Workshop Review of Session 1 – Writing the statistical model.

The learning goal in Session 1 was to write a statistical modal to address a research question.

This replaces the search for the "right test."

Once learned, we can write a model for which we do not know the name.
For example, students can execute a latin square design, even though they do not know the name of the test.

Along the way, we learned several important concepts:
Separating response from explanatory variables
Using parameters to relate response to explanatory variables.
Identifying categorical (ANOVA) and ratio scale (regression) variables.
Using contrasts to compare means of a categorical variable.
Partitioning the degrees of freedom in an ANOVA table

We set up the model for four examples – two regressions, an ANOVA, and an ANCOVA.

In Session 2 we will use a generic recipe for statistical analysis, based on writing the model.

The recipe will be demonstrated for regression, using the first example, phosphorus content in corn.

You will apply this to the second example, fly heterozygosity, the second example of regression.

The recipe will then be demonstrated for ANOVA, using the third example, the pea section data.

You will then apply this to a new example, oat yields for treated and untreated plants.

As time permits, the fourth example (ANCOVA) will be demonstrated while you carry it out in the statistical package.

Table 8.3 Generic Recipe for Statistical Inference with the General Linear Model.

1. Construct model. Begin with verbal and graphical model.
   Distinguish response from explanatory variables
   Assign symbols, state units and type of measurement scale for each.
   Write out statistical model.
2. Execute model Place data in model format, code model statement.
   Compute fitted values from parameter estimates.
   Compute residuals and plot against fitted values.
3. Evaluate the model, using residuals.
   If straight line inappropriate, revise the model (back to step 1).
   If errors not homogeneous, consider using generalized linear model (step 1)
   If n small, evaluate assumptions for using chisquare, t, or F distribution.
   residuals homogeneous ? (residual versus fit plot)
   residuals independent ? (plot residuals versus residuals at lag 1)
   residuals normal ? (histogram of residuals, quantile or normal score plot)
   If not met, empirical distribution (by randomization) may be necessary
4. Partition df and SS according to model. Calculate likelihood ratio for omnibus model.
   State the full (null) and reduced (alternative) model pair
5. State population and whether the sample is representative
   Decide on mode of inference. Is hypothesis testing appropriate?
   If yes step 6, otherwise, calculate and report the likelihood ratio with parameter estimates.
6. State test statistic, its distribution (*t* or *F*), and tolerance of Type I error.
7. ANOVA: Table Source, SS, df, MS, F-ratio.
   Obtain Type I error (p-value) from distribution (*F* or t).
8. Recompute p-value if necessary.
   If assumptions not met compute better p-value by randomization if:
   sample small ($n < 30$) and if p near α.
9. Declare decision about model terms: If $p < \alpha$ then reject H_o in favor of H_A
   If $p \geq \alpha$ then can't reject H_o
   Report conclusion with evidence: Either the ANOVA table or
   F-ratio (df1,df2) or t-statistics (df) and p-value (not α) for terms of interest.
10. Report and interpret parameters of biological interest (means, slopes)
    along with one measure of uncertainty (st. error, st. dev., or conf. intervals).
    Use appropriate distribution (step 8) to compute confidence limits.