An overview of the design and analysis of experiments

Arrangement of units — unrandomized factors

Completely randomized design	– No allowance made for patterns in experimental material
Randomized complete block design	– Units are grouped so as to be alike as possible, with no. plots/block = no. treats
Balanced incomplete block designs†	– Units are grouped so as to be alike as possible, with no. plots/block < no. treats
Latin squares	– Units grouped in 2 directions, with no. rows = no. cols = no. treats
Youden square designs†	– Units grouped in 2 directions, with no. rows = no. treats and no. cols < no. treats
Split-plot experiments	– Units, arranged in one of the above designs, are split into subunits

†nonorthogonal designs that are not covered in these notes

Note that these designs differ in the restrictions placed on randomization and whether or not a complete set of treatments is observed within blocking units.

Determining the treatments — randomized factors

Single treatment factor	– Have only one factor to investigate
Factorial Experiments	– Used to investigate more than one factor
Factorial Designs at 2 levels	– Used when have a large number of factors and want to determine which affect response
Unreplicated 2^k experiments	– Used when have a large number of factors and replication expensive
Confounded 2^k experiments	– Used when cannot fit all treatment combinations in a single block
Fractional 2^k experiments	– Used when have at least 3 factors and can't afford all treatment combinations or want to do sequential experimentation
Split-plot	– A factorial experiment in which factors are randomized to different-sized units because of physical limitations or differences in behaviour or interest in the factors.

Sample size and power

Number of (pure) replicates of each treatment combination to include in the experiment so as to detect a specified minimum treatment difference with the prescribed power and given the uncontrolled variation affecting the treatment differences.

Analysis elements

Initial graphical exploration – Use boxplots if a single treatment factor or interaction plots in factorial experiments to examine the data.

ANOVA – Used, when the treatments are replicated, to determine the appropriate model to describe the response variable. Expected mean squares tell us which mean squares to use in the F ratios of mean squares. Fixed versus random factors are important to expected mean squares.

Half normal plot of Yate's effects – Used to choose model in unreplicated, unreplicated-confounded and fractional 2^k experiments.

Tests for main effect and interactions – Used when more than one treatment factor to determine the appropriate model, and hence which tables of means are relevant. Only test for main effects when interaction not significant.

Examination of treatment differences

Multiple comparisons of all treatment differences (MCA) – Used with terms involving only qualitative factors to examine, in detail, the effects of the factors; examine only tables for significant terms and then only if not marginal to another significant term.

Polynomial submodels – Used with terms involving at least one quantitative factor to characterise the response; include lower order terms irrespective of whether significant.

Diagnostic checking of the residuals – Normal probability, residuals-versus-fitted-values and residuals-versus-factors plots and Tukey's one-degree-of-freedom-for-nonadditivity (the latter not applicable for CRDs).

Transformations – Method for adjusting to unmet assumptions.