Null Hypotheses

- Fixed effects models
  - No difference among marginal means for main effects, each pooling over the levels of the other main effect
  - Cell means minus means for each factor plus mean of Y = zero
- Random effects models
  - Main effects- no added variance due to all possible levels of each factor that could be used
  - Interaction- no added variance due to interaction effects between all possible levels of each factor that could be used
- Mixed model
  - Factor A fixed: no difference among marginal means for main effects, pooling over levels of the other main effect
  - Factor B random: no added variance due to all possible levels of factor B that could be used
  - Interaction random: no added variance due to any interaction effects between fixed levels of A and all possible levels of B that could be used. Random because interaction represents a subset of all possible interactions between A and B.

Balanced versus unbalanced designs

- In balanced designs, marginal means used to test main effects
- Each mean is weighted equally because sample sizes are equal
- SS for effects add up to total model and least squares means equal ‘raw’ means
- When designs are unbalanced,
  - Need to decide whether to use unweighted means, despite sample size differences
  - SS for effects no longer add up
  - Least squares means do not equal group means
  - Problems estimating standard errors and previous two effects become much more prominent with increasing imbalance