**ANS 6905 – Applied Statistics for Animal Sciences (FALL 2019)**

**LAB 9 – general outline – Mixed Effects Models**

***Lihe Liu, Mackenzie Dickson, Hugo Monteiro***

**Objectives:**

* Understand the difference between fixed and random effects
* Remember the basic principles of ANOVA- within vs between variance
* Know how to write models for different experimental designs (RCBD, split-plot etc.)
* Know how to analyze repeated measures
* Remember to use the correct error term (denominator) for your F test. This is imperative to correctly analyzing your data!

**Steps:**

1 – Save the file that is available online on your computer.

2 – Import the file to your program (SAS/R). Each program has its own specifics on how to import datasets. You can search online on how to do that.

3 – Take a look at the data you imported – is it correct?

4 – Define which one is the response variable, and which one (s) is (are) the predictor (s), and which parameters are fixed and random. Write down the model.

5 – Prepare the dataset for modelling. Usually it is convenient to sort the response variable in ascending order.

**Details for the mixed effects models:**

* **Which parameters are random and fixed? How do you make these decisions and how does this change your interpretation of results?**
* **What is the proper error term for each parameter?**
* **If you’re using repeated measures, what is your experimental unit (subject)? How many observations do you have? What is your covariance structure?**

6 – First step: Assign parameters as fixed or random.

* Think: If you repeated this experiment would you use the same levels? What are you trying to gain from using this parameter?
* Generally “treatment” is a fixed effect while blocks are random effects.

7 – Run the model.

* What is your model? How many parameters do you have?
* This is the same as a general linear model except not you’re adding random-effects parameter (γ)
* Verify your degrees of freedom.

8 – Double-check error terms and F tests.

* What we have learned: fixed-effects models have only 1 error term (MSE)
* Mixed effects models may have more than one! Don’t want to inflate df and interpret results incorrectly.
* Generally, for repeated measures, the treatment will be tested with the error term of subject and blocks as random effects will be tested against another error term.

9 – Split-plot designs (type of mixed model)

* Factorial design of treatments with two levels of experimental units, leading to restricted randomization or a block design with 2 levels
* The whole plot and sub plot have different error terms

10 – Repeated measures: defining and deciding the correct covariance structure.

* How did you collect your observations over time? Equally or unequally spaced apart? Random?
* Do you have homogeneous (use compound structure) or heterogenous variances and covariances (could use multiple structures)? Asses the following to help you determine the appropriate covariance structure:
  + Variance across measurements or periods
  + Covariance between measurements or periods
  + Assumption about covariance between measurements on different subjects
* Ultimately decide using fit statistics (AICc (small sample size), AIC, or BIC). Remember the smaller the number the better.

**Other notes for repeated measures covariance structures:**

* Data appropriate for mixed models: RCBD, change over design (Latin square), multicentered/multiple locations, clustered, repeated measures, longitudinal
* VCOV means variance-covariance.
* P = # parameters in model and t = # of observations within subject
* so an example: VCOV = for unstructured
  + know these formulas for the exam!
* Know the different covariance structures and when to use them. These include compound symmetry, unstructured, autoregressive, Toeplitz, spatial power.
* Understand a split-plot design and how to analyze the data (the numerator and denominator for F test). Conceptually this will help understand the various error terms point.