STAT 461: Homework 9

Name: Kyle Salitrik | ***ID#:*** *997543474* | ***PSU ID:*** *kps168*

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Problem 1

Factor	Fixed/Random	Nested/Crossed	Levels
State (s)	Random	Crossed w/ type	NY, PA, VT
Type (t)	Fixed	Crossed w/ state	Ag, Forest
Lake (l)	Random	Replicate	1,2,3,4

$$Y_{stl} = \mu + \alpha_s + \beta_t + \epsilon_{stl}$$
$$\epsilon_{stl} \sim N(0, \sigma^2)$$
$$\alpha_s \sim N(0, \sigma^2_{state})$$

Problem 2

Factor	Fixed/Random	Nested/Crossed	Levels
Type (t)	Fixed	Crossed with paint	Mountain, City
Road (r)	Random	Nested in Type	1, 2, 3, 4, 5, 6, 7, 8, 9, 10
Paint (p)	Fixed	Crossed with road	Reflective, Non-Reflective
Year (y)	Random	Replicate	1,2,3

$$Y_{trpy} = \mu + \alpha_t + \beta_{r(t)} + \gamma_p + (\alpha\beta)_{tp} + \epsilon_{trpy}$$
$$\epsilon_{ijt} \sim N(0, \sigma^2)$$
$$\beta_{r(t)} \sim N(0, \sigma^2_{road})$$

Problem 3

Factor	Fixed/Random	Nested/Crossed	Levels
Store (s)	Random	Crossed with display	1,2,3,4
Display (r)	Fixed	Crossed with store	Yes, No
Week (w)	Random	Replicate	1,2,3,4

$$Y_{srw} = \mu + \alpha_s + \beta_r + \epsilon_{srw}$$
$$\epsilon_{srw} \sim N(0, \sigma^2)$$
$$\alpha_s \sim N(0, \sigma^2_{store})$$

```
> displayModel = lmer(sales ~ (1|store) + display, data=displays)
> anova(displayModel)
Type III Analysis of Variance Table with Satterthwaite's method
        Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
display 266085  266085     1    27  119.17 2.095e-11 ***
---
Signif. codes:  0 Ś***Š 0.001 Ś**Š 0.01 Ś*Š 0.05 Ś.Š 0.1 Ś Š 1
> ranova(displayModel)
ANOVA-like table for random-effects: Single term deletions

Model:
sales ~ display + (1 | store)
             npar  logLik    AIC    LRT Df Pr(>Chisq)
<none>          4 -170.16 348.33
(1 | store)     3 -218.34 442.68 96.354  1  < 2.2e-16 ***
---
Signif. codes:  0 Ś***Š 0.001 Ś**Š 0.01 Ś*Š 0.05 Ś.Š 0.1 Ś Š 1
```

Listing 1: Fixed and Random Effect ANOVA

```
> contrast(displayLSM, method="pairwise")
 contrast estimate      SE df t.ratio p.value
 No - Yes  -182.375 16.7065 27 -10.916  <.0001
```

Listing 2: Pairwise Results for Display

Looking at the ANOVA tables, we can see that both the fixed and random factors are significant. While performing a pairwise comparison on store is irrelevant, we can look at the difference using a display makes. Because we have a negative value for "No - Yes", we can conclude that the average sales while using a display are higher than average sales without a display.

Code Appendix

```
################################################################################
#### Setup
################################################################################
## Install and load libraries
# ipak function taken from: https://gist.github.com/stevenworthington/3178163
ipak = function(pkg) {
  new.pkg = pkg[!(pkg %in% installed.packages()[, "Package"])]
  if (length(new.pkg))
    install.packages(new.pkg, dependencies = TRUE)
  sapply(pkg, require, character.only = TRUE)
}
packages = c("ggplot2","ggplotify", "reshape2", "gridExtra", "TSA", "astsa",
             "orcutt", "nlme", "fGarch", "vars", "lsmeans", "multcompView",
             "base2grob", "lme4", "lmerTest")
ipak(packages)

################################################################################
#### Problem 3
################################################################################
########################################
#### Data Input
########################################
displays=read.table("displays.dat",header=TRUE)
displays$store=as.factor(displays$store)
displays$week=as.factor(displays$week)
displays

########################################
#### Model
########################################
displayModel = lmer(sales ~ (1|store) + display, data=displays)
anova(displayModel)
ranova(displayModel)

displayLSM = lsmeans(displayModel, ~ display)
contrast(displayLSM, method="pairwise")
```