Coding Challenge 7

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Question 1

```
library(readr)
Plant.Emerge <- read.csv("PlantEmergence.csv")
```

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v purrr     1.0.4
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.4     v tidyr     1.3.1
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(lme4)
```

```
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
##
## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack
```

```
library(emmeans)
```

```
## Warning: package 'emmeans' was built under R version 4.4.3
```

```
## Welcome to emmeans.
## Caution: You lose important information if you filter this package's results.
## See '? untidy'
```

```r
library(multcomp)
```

```
## Warning: package 'multcomp' was built under R version 4.4.3
```

```
## Loading required package: mvtnorm
```

```
## Warning: package 'mvtnorm' was built under R version 4.4.3
```

```
## Loading required package: survival
## Loading required package: TH.data
```

```
## Warning: package 'TH.data' was built under R version 4.4.3
```

```
## Loading required package: MASS
##
## Attaching package: 'MASS'
##
## The following object is masked from 'package:dplyr':
##
##     select
##
##
## Attaching package: 'TH.data'
##
## The following object is masked from 'package:MASS':
##
##     geyser
```

```r
library(multcompView)
```

```
## Warning: package 'multcompView' was built under R version 4.4.3
```

```r
Plant.Emerge$Treatment <- as.factor(Plant.Emerge$Treatment)
Plant.Emerge$DaysAfterPlanting <- as.factor(Plant.Emerge$DaysAfterPlanting)
Plant.Emerge$Rep <- as.factor(Plant.Emerge$Rep)
```

Question 2

```r
Emerge.Model <- lm(Emergence~Treatment*DaysAfterPlanting, Plant.Emerge)
summary(Emerge.Model)
```

```
##
## Call:
## lm(formula = Emergence ~ Treatment * DaysAfterPlanting, data = Plant.Emerge)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -21.250  -6.062  -0.875   6.750  21.875
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     1.823e+02  5.324e+00  34.229   <2e-16 ***
## Treatment2                     -1.365e+02  7.530e+00 -18.128   <2e-16 ***
## Treatment3                      1.112e+01  7.530e+00   1.477    0.142
## Treatment4                      2.500e+00  7.530e+00   0.332    0.741
## Treatment5                      8.750e+00  7.530e+00   1.162    0.248
## Treatment6                      7.000e+00  7.530e+00   0.930    0.355
## Treatment7                     -1.250e-01  7.530e+00  -0.017    0.987
## Treatment8                      9.125e+00  7.530e+00   1.212    0.228
## Treatment9                      2.375e+00  7.530e+00   0.315    0.753
## DaysAfterPlanting14             1.000e+01  7.530e+00   1.328    0.187
## DaysAfterPlanting21             1.062e+01  7.530e+00   1.411    0.161
## DaysAfterPlanting28             1.100e+01  7.530e+00   1.461    0.147
## Treatment2:DaysAfterPlanting14  1.625e+00  1.065e+01   0.153    0.879
## Treatment3:DaysAfterPlanting14 -2.625e+00  1.065e+01  -0.247    0.806
## Treatment4:DaysAfterPlanting14 -6.250e-01  1.065e+01  -0.059    0.953
## Treatment5:DaysAfterPlanting14  2.500e+00  1.065e+01   0.235    0.815
## Treatment6:DaysAfterPlanting14  1.000e+00  1.065e+01   0.094    0.925
## Treatment7:DaysAfterPlanting14 -2.500e+00  1.065e+01  -0.235    0.815
## Treatment8:DaysAfterPlanting14 -2.500e+00  1.065e+01  -0.235    0.815
## Treatment9:DaysAfterPlanting14  6.250e-01  1.065e+01   0.059    0.953
## Treatment2:DaysAfterPlanting21  3.500e+00  1.065e+01   0.329    0.743
## Treatment3:DaysAfterPlanting21 -1.000e+00  1.065e+01  -0.094    0.925
## Treatment4:DaysAfterPlanting21  1.500e+00  1.065e+01   0.141    0.888
## Treatment5:DaysAfterPlanting21  2.875e+00  1.065e+01   0.270    0.788
## Treatment6:DaysAfterPlanting21  4.125e+00  1.065e+01   0.387    0.699
## Treatment7:DaysAfterPlanting21 -2.125e+00  1.065e+01  -0.200    0.842
## Treatment8:DaysAfterPlanting21 -1.500e+00  1.065e+01  -0.141    0.888
## Treatment9:DaysAfterPlanting21 -1.250e+00  1.065e+01  -0.117    0.907
## Treatment2:DaysAfterPlanting28  2.750e+00  1.065e+01   0.258    0.797
## Treatment3:DaysAfterPlanting28 -1.875e+00  1.065e+01  -0.176    0.861
## Treatment4:DaysAfterPlanting28  3.264e-13  1.065e+01   0.000    1.000
## Treatment5:DaysAfterPlanting28  2.500e+00  1.065e+01   0.235    0.815
## Treatment6:DaysAfterPlanting28  2.125e+00  1.065e+01   0.200    0.842
## Treatment7:DaysAfterPlanting28 -3.625e+00  1.065e+01  -0.340    0.734
## Treatment8:DaysAfterPlanting28 -1.500e+00  1.065e+01  -0.141    0.888
## Treatment9:DaysAfterPlanting28 -8.750e-01  1.065e+01  -0.082    0.935
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 10.65 on 108 degrees of freedom
## Multiple R-squared:  0.9585, Adjusted R-squared:  0.945
## F-statistic: 71.21 on 35 and 108 DF,  p-value: < 2.2e-16
```

```
anova(Emerge.Model)
```

```
## Analysis of Variance Table
##
## Response: Emergence
##                             Df Sum Sq Mean Sq  F value    Pr(>F)
## Treatment                    8 279366   34921 307.9516 < 2.2e-16 ***
```

```
## DaysAfterPlanting             3   3116    1039   9.1603 1.877e-05 ***
## Treatment:DaysAfterPlanting  24    142       6   0.0522         1
## Residuals                   108  12247     113
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Question 3

```
Emerge.Simp.Model <- lm(Emergence~Treatment+DaysAfterPlanting, Plant.Emerge)
summary(Emerge.Simp.Model)
```

```
##
## Call:
## lm(formula = Emergence ~ Treatment + DaysAfterPlanting, data = Plant.Emerge)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -21.1632  -6.1536  -0.8542   6.1823  21.3958
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)          182.163      2.797  65.136  < 2e-16 ***
## Treatment2          -134.531      3.425 -39.277  < 2e-16 ***
## Treatment3             9.750      3.425   2.847  0.00513 **
## Treatment4             2.719      3.425   0.794  0.42876
## Treatment5            10.719      3.425   3.129  0.00216 **
## Treatment6             8.812      3.425   2.573  0.01119 *
## Treatment7            -2.188      3.425  -0.639  0.52416
## Treatment8             7.750      3.425   2.263  0.02529 *
## Treatment9             2.000      3.425   0.584  0.56028
## DaysAfterPlanting14    9.722      2.283   4.258 3.89e-05 ***
## DaysAfterPlanting21   11.306      2.283   4.951 2.21e-06 ***
## DaysAfterPlanting28   10.944      2.283   4.793 4.36e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.688 on 132 degrees of freedom
## Multiple R-squared:  0.958,  Adjusted R-squared:  0.9545
## F-statistic: 273.6 on 11 and 132 DF,  p-value: < 2.2e-16
```

```
anova(Emerge.Simp.Model)
```

```
## Analysis of Variance Table
##
## Response: Emergence
##                     Df Sum Sq Mean Sq F value    Pr(>F)
## Treatment           8 279366   34921 372.070 < 2.2e-16 ***
## DaysAfterPlanting   3   3116    1039  11.068 1.575e-06 ***
## Residuals         132  12389      94
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Question 4

```
LSM.Treatment <- emmeans(Emerge.Model, ~ Treatment)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
summary(LSM.Treatment)
```

```
##  Treatment emmean   SE  df lower.CL upper.CL
##  1          190.2 2.66 108    184.9    195.4
##  2           55.6 2.66 108     50.3     60.9
##  3          199.9 2.66 108    194.6    205.2
##  4          192.9 2.66 108    187.6    198.2
##  5          200.9 2.66 108    195.6    206.2
##  6          199.0 2.66 108    193.7    204.2
##  7          188.0 2.66 108    182.7    193.2
##  8          197.9 2.66 108    192.6    203.2
##  9          192.2 2.66 108    186.9    197.4
##
## Results are averaged over the levels of: DaysAfterPlanting
## Confidence level used: 0.95
```

```
turkey_result <- cld(LSM.Treatment)
turkey_result
```

```
##  Treatment emmean   SE  df lower.CL upper.CL .group
##  2           55.6 2.66 108     50.3     60.9  1
##  7          188.0 2.66 108    182.7    193.2   2
##  1          190.2 2.66 108    184.9    195.4   23
##  9          192.2 2.66 108    186.9    197.4   23
##  4          192.9 2.66 108    187.6    198.2   23
##  8          197.9 2.66 108    192.6    203.2   23
##  6          199.0 2.66 108    193.7    204.2   23
##  3          199.9 2.66 108    194.6    205.2    3
##  5          200.9 2.66 108    195.6    206.2    3
##
## Results are averaged over the levels of: DaysAfterPlanting
## Confidence level used: 0.95
## P value adjustment: tukey method for comparing a family of 9 estimates
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
##       then we cannot show them to be different.
##       But we also did not show them to be the same.
```

Question 5

```r
plot_cldbars_onefactor <- function(lm_model, factor) {
  data <- lm_model$model
  variables <- colnames(lm_model$model)
  dependent_var <- variables[1]
  independent_var <- variables[2:length(variables)]

  lsmeans <- emmeans(lm_model, as.formula(paste("~", factor))) # estimate lsmeans
  Results_lsmeans <- cld(lsmeans, alpha = 0.05, reversed = TRUE, details = TRUE, Letters = letters) # c
# Extracting the letters for the bars
  sig.diff.letters <- data.frame(Results_lsmeans$emmeans[,1],
                                 str_trim(Results_lsmeans$emmeans[,7]))
  colnames(sig.diff.letters) <- c(factor, "Letters")

  # for plotting with letters from significance test
  ave_stand2 <- lm_model$model %>%
    group_by(!!sym(factor)) %>%
    dplyr::summarize(
      ave.emerge = mean(.data[[dependent_var]], na.rm = TRUE),
      se = sd(.data[[dependent_var]]) / sqrt(n())
    ) %>%
    left_join(sig.diff.letters, by = factor) %>%
    mutate(letter_position = ave.emerge + 10 * se)

  plot <- ggplot(data, aes(x = !! sym(factor), y = !! sym(dependent_var))) +
    stat_summary(fun = mean, geom = "bar") +
    stat_summary(fun.data = mean_se, geom = "errorbar", width = 0.5) +
    ylab("Number of emerged plants") +
    geom_jitter(width = 0.02, alpha = 0.5) +
    geom_text(data = ave_stand2, aes(label = Letters, y = letter_position), size = 5) +
    xlab(as.character(factor)) +
    theme_classic()

  return(plot)
}
```

Question 6

https://github.com/alh0062/PLPA-6820/tree/main/Coding%20Challenge%207