STA 522 Project 2

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Experimental Design

We decided to use a full factorial design so that we can estimate any interaction we want from the data. Dropping paper helicopters does not take a long time; 2^4 configurations was a reasonable drain on our resources (time). We dropped each helicopter configuration four times in a random order from a height of five feet.

The Data Collection Part

```
if(!file.exists("full-data.Rdata")){
  # setup the data matrix
# 1 = high (treatment setting), 0 = low (control) setting
obs = data.frame(
  Rotor_Length = rep(c(rep(0,4), rep(1,4)), 8),
  Leg_Length = rep(c(rep(0,8), rep(1,8)), 4),
  Leg_Width = rep(c(rep(0,16), rep(1,16)), 2),
  Paper_Clip = c(rep(0,32), rep(1,32)),
  time = NA
)
DanielData = obs %>% filter(Paper_Clip == 1)
set.seed(2018)
DropOrder = sample_n(DanielData, 32)
DanielData[as.numeric(rownames(DropOrder)),"time"] =
  c(1.27,1.45,0.85,1.44,1.56,1.18,1.37,0.95,1.04,1.32,1.26,1.02,1.19,0.92,1.14,0.92,
    1.35,1.16,0.87,0.95,1.05,1.56,1.22,0.92,1.10,1.26,1.17,1.10,1.10,1.10,1.58,0.94)
save(DanielData, file = "daniel-drop-data.Rdata")
obs[33:64,"time"] = DanielData$time
#save(obs, file = "full-data.Rdata")

no_legclip_time = c(1, 1.22, 0.98, 1.12, 1.41, 1.37, 1.52, 1.45, 1.25, 1.18,
1.39, 1.28, 1.58, 1.62, 1.49, 1.64, 1.14, 1.21, 1.16, 1.23, 1.21, 1.19, 1.16,
1.18, 1.15, 1.28, 1.29, 1.31, 1.18, 1.24, 1.17, 1.09)
obs[1:32, "time"] = no_legclip_time

save(obs, file = "full-data.Rdata")
}
```

The Analysis

```
load("full-data.Rdata")
effects = lm(time ~ Rotor_Length + Leg_Length + Leg_Width + Paper_Clip +
               Rotor_Length:Leg_Length + Rotor_Length:Leg_Width + Rotor_Length:Paper_Clip +
               Leg_Length:Leg_Width + Leg_Length:Paper_Clip +
               Leg_Width:Paper_Clip,
             data = obs)
summary(effects)
```

```
##
## Call:
## lm(formula = time ~ Rotor_Length + Leg_Length + Leg_Width + Paper_Clip +
##     Rotor_Length:Leg_Length + Rotor_Length:Leg_Width + Rotor_Length:Paper_Clip +
##     Leg_Length:Leg_Width + Leg_Length:Paper_Clip + Leg_Width:Paper_Clip,
##     data = obs)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.171875 -0.070781  0.001563  0.058281  0.197500
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)              1.06813    0.03978  26.848  < 2e-16 ***
## Rotor_Length             0.40062    0.04798   8.349 3.11e-11 ***
## Leg_Length               0.20875    0.04798   4.351 6.21e-05 ***
## Leg_Width                0.10500    0.04798   2.188   0.0331 *
## Paper_Clip              -0.06625    0.04798  -1.381   0.1732
## Rotor_Length:Leg_Length -0.11625    0.04798  -2.423   0.0189 *
## Rotor_Length:Leg_Width  -0.39625    0.04798  -8.258 4.34e-11 ***
## Rotor_Length:Paper_Clip  0.01375    0.04798   0.287   0.7756
## Leg_Length:Leg_Width    -0.10250    0.04798  -2.136   0.0373 *
## Leg_Length:Paper_Clip   -0.02750    0.04798  -0.573   0.5690
## Leg_Width:Paper_Clip    -0.06500    0.04798  -1.355   0.1813
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.09596 on 53 degrees of freedom
## Multiple R-squared:  0.7962, Adjusted R-squared:  0.7578
## F-statistic: 20.71 on 10 and 53 DF,  p-value: 6.035e-15
```

Question 1

From the coefficients and standard errors of our linear model, we find that the most important factors for longer flight are rotor length, leg length, leg width, rotor length - leg length interaction, rotor length - leg width interaction, and leg length - leg width interaction. The standard errors for these estimates are small compared to the respective estimates which is why we think their effects on the flight time (the response variable) are significant.

Table 1: Effects of important factors on flight time

	2.5%	Estimate	97.5%
Rotor_Length	0.304	0.401	0.497
Leg_Length	0.113	0.209	0.305
Leg_Width	0.009	0.105	0.201
Rotor_Length:Leg_Length	-0.212	-0.116	-0.020
Rotor_Length:Leg_Width	-0.492	-0.396	-0.300
Leg_Length:Leg_Width	-0.199	-0.102	-0.006

Question 2

There is evidence that the effect of rotor length differs by leg width. When leg width is in the low setting, rotor length has the following effects on flight time.

Table 2: Effects of Rotor Length with Leg Width at Low Setting

2.5%	Estimate	97.5%
0.304	0.401	0.497

When leg width is in the high setting, the effect of rotor length changes as indicated by the interaction term.

Table 3: Change in Rotor Length Effect when Leg Width is High

2.5%	Fit	97.5%
-0.492	-0.396	-0.3

Table 4: Effects of Rotor Lenght on Flight Time

With Low Leg Width	With High Leg Width
0.401	0.004

Question 3

In our regression, we have assumed that the three-way and four-way interactions are zero. With that in mind, the optimal combination is to use the high setting on rotor length, the high setting on leg length, the low setting on leg width, and no paper clip.

Table 5: Predicted Flight Time of Helicopter Based on Configuration

Rotor Length	Leg Length	Leg Width	Paper Clip	Predicted Flight Time
0	0	0	0	1.07
1	0	0	0	1.47
0	1	0	0	1.28
1	1	0	0	1.56
0	0	1	0	1.17
1	0	1	0	1.18
0	1	1	0	1.28
1	1	1	0	1.17
0	0	0	1	1.00
1	0	0	1	1.42
0	1	0	1	1.18
1	1	0	1	1.48
0	0	1	1	1.04
1	0	1	1	1.06
0	1	1	1	1.12
1	1	1	1	1.02