Advanced Stats HW 1

Joel Vasama — 6012872

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Question 1 — Effect size

a.

$$s_p = \sqrt{\frac{(814-1)49 + (854-1)38.4}{(814-1)+(854-1)}} = \sqrt{\frac{39837 + 32755.2}{1666}} \approx \sqrt{43.57} \approx 6.6$$

$$d = \frac{177.7cm - 165.1cm}{6.6} \approx 1.91$$

b.

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s_p} \text{, where } \bar{x}_{1,2} \text{ are means of each sample, and } s_p \text{ is their pooled variance}$$

c.

An effect size of 1.91 is definitely a large effect

Question 2 — Effect Size and Significance

$$d = t_b\sqrt{\frac{2}{n}} \rightarrow 0.2 = t_b\sqrt{\frac{2}{72}} = t_b \cdot \frac{1}{6} \rightarrow t_b = \frac{0.2}{\frac{1}{6}} = 1.2$$

Not significant at two-tailed alpha of 0.05 (*t*-threshold = 1.96)

Question 3 — Effect Size and Correlation

Using Paired-Samples *t*-test due to reduced variance

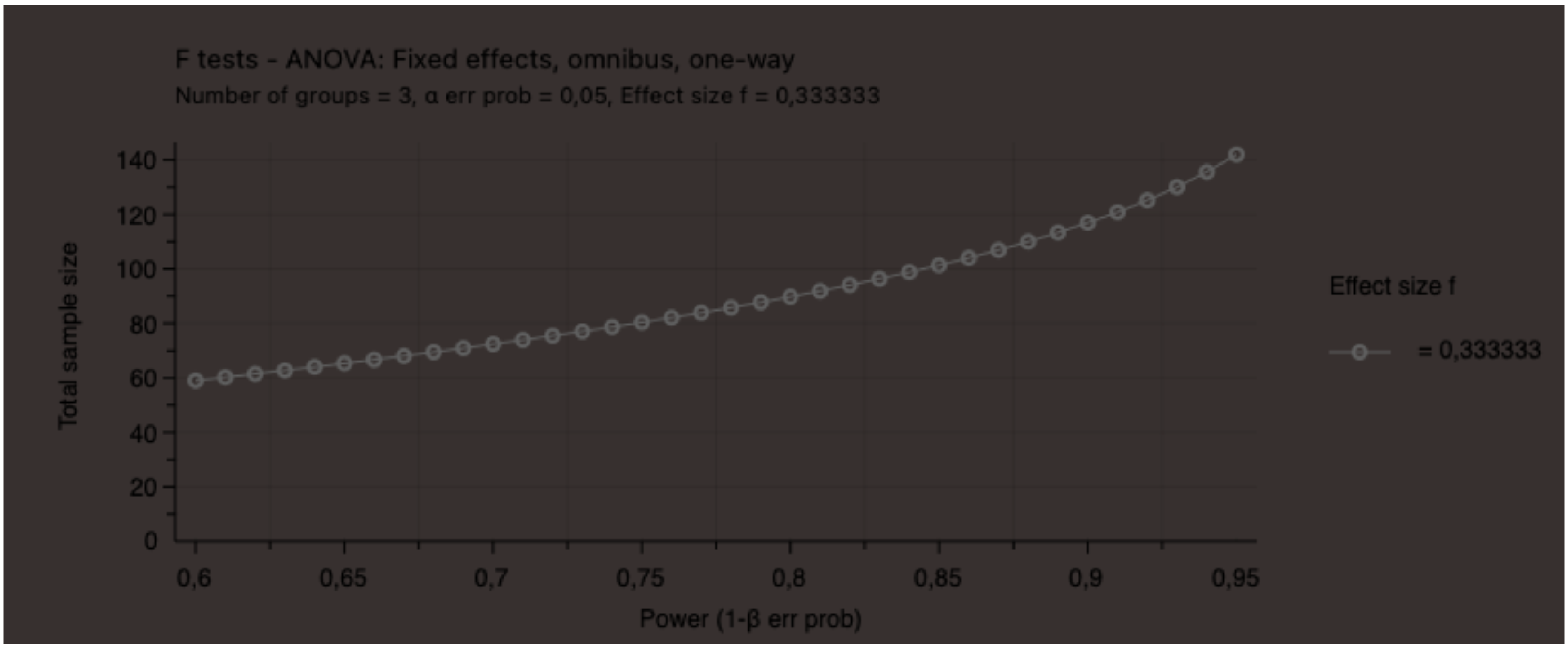
$$d_{RM,pooled} = 0.066$$

Question 4 — Effect Size and Power

a.

At effect size f = 1/3 ≈ 0.33 (estimated from Partial Eta^2 = 0.1), total sample size required is N = 117 at power >= 0.9 and alpha = 0.05, for a three-way ANOVA

b.



Power estimation based on sample and effect size

c.

At effect size f = 0.1, total sample size required is N = 1269 at power = 0.9 and alpha = 0.05, for a three-way ANOVA

Question 5 — Multiple testing

No correction

```
alpha <- 0.05 # Set alpha

table1$nc_alpha <- ifelse(table1$p < alpha, 1, 0) # Code passing p-values

# Collect passed, false positives, and false negatives
nc_p <- which(table1$nc_alpha == 1)
nc_fp <- which(table1$PopulationEffect == 0 & table1$nc_alpha == 1)
nc_fn <- which(table1$PopulationEffect == 1 & table1$nc_alpha == 0)
```

Without correction
- Pass with alpha (0.05): 2, 3, 4, 9, 12, 17, 18, 22, 28, 30, 32
- False positives: 18
- False negatives:

Bonferroni FWE correction

```
alpha <- 0.05 / nrow(table1) # Set Bonferroni alpha

table1$Bonf_FWE <- ifelse(table1$p < alpha, 1, 0) # Code passing p-values

# Collect passed, false positives, and false negatives
Bonf_p <- which(table1$Bonf_FWE == 1)
Bonf_fp <- which(table1$PopulationEffect == 0 & table1$Bonf_FWE == 1)
Bonf_fn <- which(table1$PopulationEffect == 1 & table1$Bonf_FWE == 0)
```

With Bonferroni FWE correction
- Pass with alpha (0.00125): 2, 3, 4, 22
- False positives:

- False negatives: 9, 12, 17, 28, 30, 32

Bonferroni-Holm FWE correction

```
table1$Ind <- c(1:40) # Save original index order

table1 <- table1[order(table1$p, decreasing = FALSE),] # Set ascending order

BonHolm_FWE <- rep(NA, 40) # Pre-allocation

# Iterate through tests
for(i in 1:40){
  alpha <- 0.05 / (40 + 1 - i) # Bonferroni-Holm alpha
  BonHolm_FWE[i] <- ifelse(table1$p[i] < alpha, 1, 0)
  if(BonHolm_FWE[i] == 0){BonHolm_FWE[i:40] <- 0; break} # Exit iteration if no mo
re paases
}

table1$BonHolm_FWE <- BonHolm_FWE

table1 <- table1[order(table1$Ind, decreasing = FALSE),] # Return original order

# Collect passed, false positives, and false negatives
BonHolm_p <- which(table1$BonHolm_FWE == 1)
BonHolm_fp <- which(table1$PopulationEffect == 0 & table1$BonHolm_FWE == 1)
BonHolm_fn <- which(table1$PopulationEffect == 1 & table1$BonHolm_FWE == 0)
```

With Bonferroni-Holm FWE correction
- Pass until alpha (0.0014286): 2, 3, 4, 12, 22
- False positives:
- False negatives: 9, 17, 28, 30, 32

Benjamini-Hochberg FDR correction

```
table1 <- table1[order(table1$p, decreasing = FALSE),] # Set ascending order

BenHoc_FDR <- rep(NA, 40) # Pre-allocation

# Iterate through tests
for(i in 1:40){
  alpha <- (i / 40) * 0.05 # Benjamini-Hochberg alpha, rank == i due to ascending
 order
  BenHoc_FDR[i] <- ifelse(table1$p[i] < alpha, 1, 0)
  if(i > 1){if(BenHoc_FDR[i] == 0 & BenHoc_FDR[i - 1] == 1){alpha_FDR <- alpha}} #
Collect last alpha
}

table1$BenHoc_FDR <- BenHoc_FDR

table1 <- table1[order(table1$Ind, decreasing = FALSE),] # Return original order

# Collect passed, false positives, and false negatives
BenHoc_p <- which(table1$BenHoc_FDR == 1)
BenHoc_fp <- which(table1$PopulationEffect == 0 & table1$BenHoc_FDR == 1)
BenHoc_fn <- which(table1$PopulationEffect == 1 & table1$BenHoc_FDR == 0)
```

With Benjamini-Hochberg FDR correction
- Pass until alpha (0.0125): 2, 3, 4, 12, 17, 22, 28, 30, 32
- False positives:
- False negatives: 9

Question 6 — Bonus

With a two-tailed p = 0.048, the peak of H1 is at the upper tail of H0 (0.024), where the maximum effect size for such a result would be. This essentially is right at the center of H1, splitting it almost in half, thus providing a Beta of ~50%