# Additional Hypothesis Test Applications Solutions

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## Exercises

1. Golf balls

Repeat the analysis of the golf ball problem from earlier this semester.

a. Load the data and tally the data into a table. The data is in `golf_balls.csv`.

```
golf_balls <- read_csv("data/golf_balls.csv")
```

```
head(golf_balls)
```

```
## # A tibble: 6 x 1
##   number
##    <dbl>
## 1      3
## 2      2
## 3      1
## 4      4
## 5      4
## 6      3
```

```
tally(~number,data=golf_balls)
```

```
## number
##   1   2   3   4
## 137 138 107 104
```

b. Using the function `chisq.test` conduct a hypothesis test of equally likely distribution of balls. You may have to read the help menu.

```
chisq.test(tally(~number,data=golf_balls),p=c(.25,.25,.25,.25))
```

```
##
##  Chi-squared test for given probabilities
##
## data:  tally(~number, data = golf_balls)
## X-squared = 8.4691, df = 3, p-value = 0.03725
```

c. Repeat part b. but assume balls with the numbers 1 and 2 occur 30% of the time and balls with 3 and 4 occur 20%.

```
chisq.test(tally(~number,data=golf_balls),p=c(.3,.3,.2,.2))
```

```
##
##  Chi-squared test for given probabilities
##
## data:  tally(~number, data = golf_balls)
## X-squared = 2.4122, df = 3, p-value = 0.4914
```

2. Bootstrap hypothesis testing

Repeat the analysis of the MLB data from the lesson but this time generate a bootstrap distribution of the $F$ statistic.

First, read in the data.

```
mlb_obp <- read_csv("data/mlb_obp.csv")
```

Convert `position` to a factor.

```
mlb_obp <- mlb_obp %>%
  mutate(position=as.factor(position))
```

Summarize the data.

```
favstats(obp~position,data=mlb_obp)
```

```
##   position   min      Q1 median      Q3   max      mean         sd   n missing
## 1        C 0.219 0.30000 0.3180 0.35700 0.405 0.3226154 0.04513175  39       0
## 2       DH 0.287 0.31625 0.3525 0.36950 0.412 0.3477857 0.03603669  14       0
## 3       IF 0.174 0.30800 0.3270 0.35275 0.437 0.3315260 0.03709504 154       0
## 4       OF 0.265 0.31475 0.3345 0.35300 0.411 0.3342500 0.02944394 120       0
```

We need a function to resample the data, we will use the `resample()` from the `mosaic` package.

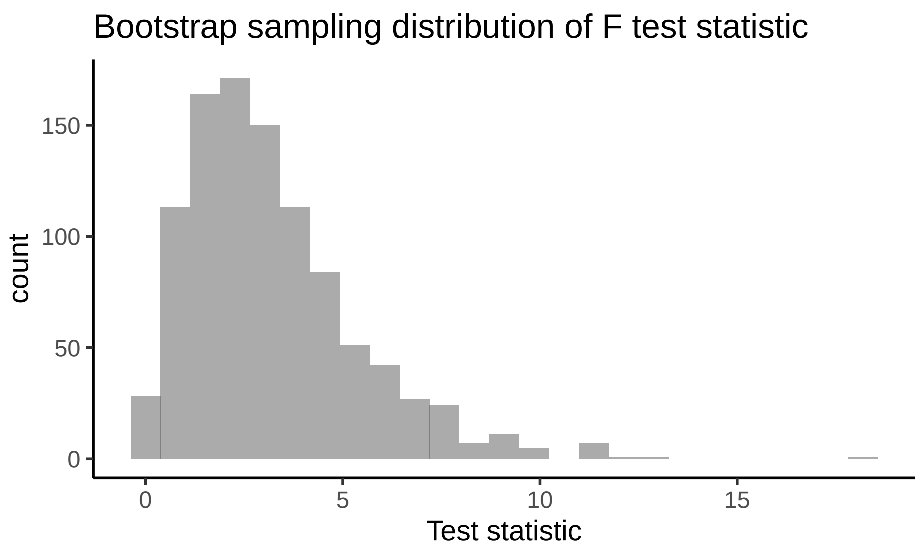
```
library(broom)
```

```
f_boot <- function(x){
  aov(obp~position,data=resample(x)) %>%
  tidy() %>%
  summarize(stat=meansq[1]/meansq[2]) %>%
  pull()
}
```

```
set.seed(541)
results<-do(1000)*f_boot(mlb_obp)
```

Let's plot our sampling distribution.

```r
results %>%
  gf_histogram(~f_boot) %>%
  gf_theme(theme_classic()) %>%
  gf_labs(title="Bootstrap sampling distribution of F test statistic",
          x="Test statistic")
```




Now the confidence interval for the F-statistic is:

```r
cdata(~f_boot,data=results)
```

```
##          lower    upper central.p
## 2.5% 0.3546682 8.724895      0.95
```

We are 95% confident that the $F$ statistic is in the interval $(0.35, 8.72)$ which includes 1 so we fail to reject.

3. Test of variance

We have not performed a test of variance so we will create our own.

a. Using the MLB from the lesson, subset on `IF` and `OF`.

```r
mlb_prob3 <- mlb_obp %>%
  filter(position=="IF"|position=="OF") %>%
  droplevels()
```

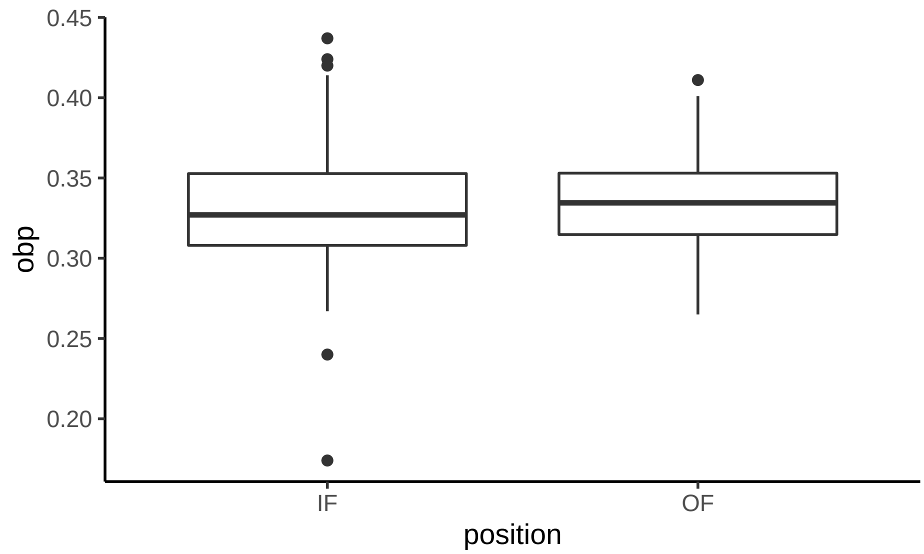
```r
summary(mlb_prob3)
```

```
##  position       obp
##  IF:154   Min.   :0.1740
##  OF:120   1st Qu.:0.3100
##           Median :0.3310
##           Mean   :0.3327
##           3rd Qu.:0.3530
##           Max.   :0.4370
```

The function `droplevels()` gets rid of `C` and `DH` in the factor levels.

b. Create a side-by-side boxplot.

```
mlb_prob3 %>%
  gf_boxplot(obp~position) %>%
  gf_theme(theme_classic())
```




The hypotheses are:
$H_0$: $\sigma^2_{IF} = \sigma^2 OF$. There is no difference in the variance of on base percentage for infielders and outfielders.
$H_A$: $\sigma^2_{IF} \neq \sigma^2 OF$. There is a difference in variances.

c. Use the differences in sample standard deviations as your test statistic. Using a permutation test, find the p-value and discuss your decision.

```
mlb_prob3 %>%
  group_by(position) %>%
  summarize(stat=sd(obp))
```

```
## `summarise()` ungrouping output (override with `.groups` argument)
```

```
## # A tibble: 2 x 2
##   position   stat
##   <fct>     <dbl>
## 1 IF       0.0371
## 2 OF       0.0294
```

```
obs <- mlb_prob3 %>%
  summarize(stat=sd(obp[position=="IF"])-sd(obp[position=="OF"])) %>%
  pull()
obs
```

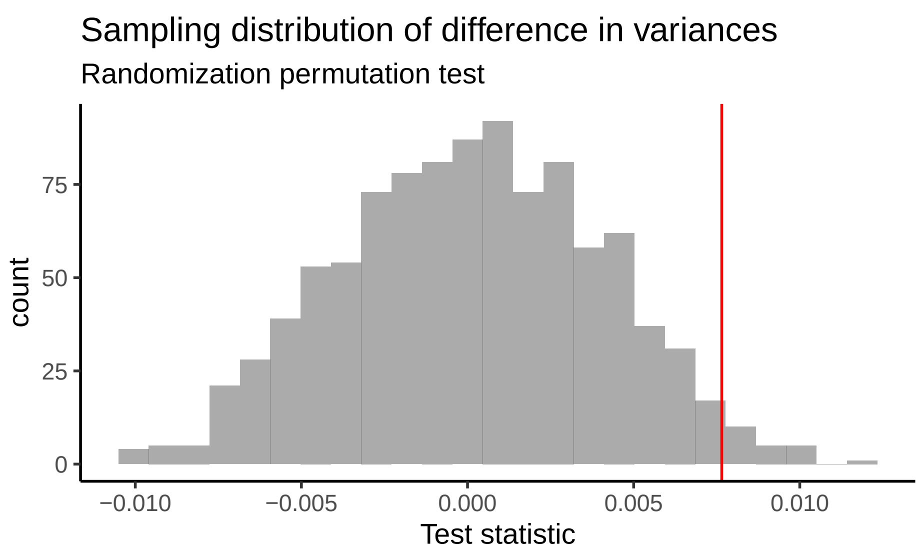
```
## [1] 0.007651101
```

Let's write a function to shuffle the position.

```
perm_stat <- function(x){
  x %>%
  mutate(position=shuffle(position)) %>%
  summarize(stat=sd(obp[position=="IF"])-sd(obp[position=="OF"])) %>%
  pull()
}
```

```
set.seed(443)
results<-do(1000)*perm_stat(mlb_prob3)
```

```
results %>%
  gf_histogram(~perm_stat) %>%
  gf_vline(xintercept=obs,color="red") %>%
  gf_theme(theme_classic()) %>%
  gf_labs(title="Sampling distribution of difference in variances",
          subtitle="Randomization permutation test",
          x="Test statistic")
```




The p-value is

```
2*prop1(~(perm_stat>=obs),data=results)
```

```
##   prop_TRUE
## 0.04395604
```

This is a two sided test since we did not know in advance which variance would be larger. We reject the hypothesis of equal variance but the p-value is too close to the significance level. The conclusion is suspect. We need more data.

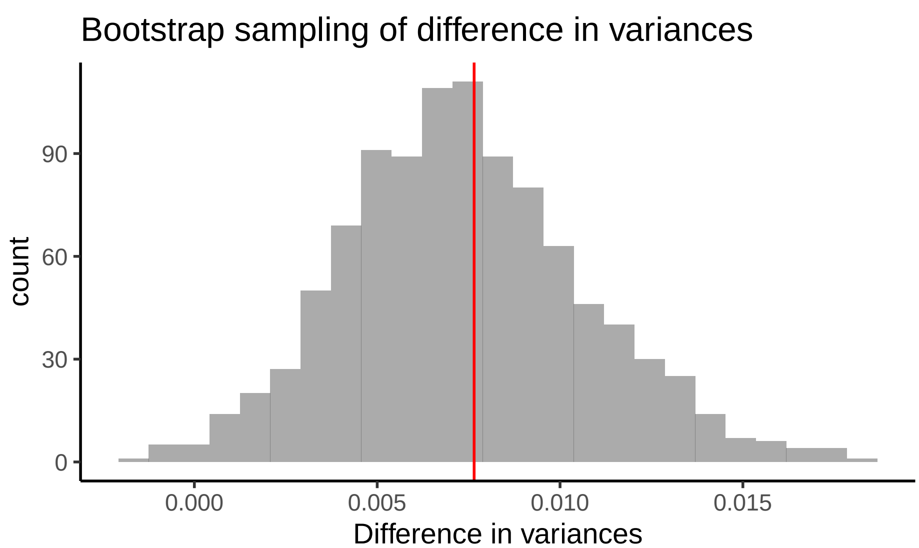
d. Create a bootstrap distribution of the differences in sample standard deviations, and report a 95% confidence interval. Compare with part c.

Let's write a function.

```
var_stat <- function(x){
  resample(x) %>%
  summarize(stat=sd(obp[position=="IF"])-sd(obp[position=="OF"])) %>%
  pull()
}
```

```
set.seed(827)
results<-do(1000)*var_stat(mlb_prob3)
```

```
results %>%
  gf_histogram(~var_stat) %>%
  gf_vline(xintercept=obs,color="red")%>%
  gf_theme(theme_classic()) %>%
  gf_labs(title="Bootstrap sampling of difference in variances",
          x="Difference in variances")
```




## File Creation Information

- File creation date: 2020-10-26
- Windows version: Windows 10 x64 (build 18362)
- R version 3.6.3 (2020-02-29)
- `mosaic` package version: 1.7.0
- `tidyverse` package version: 1.3.0
- `openintro` package version: 2.0.0
- `broom` package version: 0.7.0