IPS9 in R: Two-way analysis of variance (Chapter 13)

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Introduction and background

These documents are intended to help describe how to undertake analyses introduced as examples in the Ninth Edition of *Introduction to the Practice of Statistics* (2017) by Moore, McCabe, and Craig.

More information about the book can be found here. The data used in these documents can be found under Data Sets in the Student Site. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at https://nhorton.people.amherst.edu/ips9/.

This work leverages initiatives undertaken by Project MOSAIC (http://www.mosaic-web.org), an NSF-funded effort to improve the teaching of statistics, calculus, science and computing in the undergraduate curriculum. In particular, we utilize the `mosaic` package, which was written to simplify the use of R for introductory statistics courses. A short summary of the R needed to teach introductory statistics can be found in the mosaic package vignettes (http://cran.r-project.org/web/packages/mosaic). A paper describing the mosaic approach was published in the *R Journal*: https://journal.r-project.org/archive/2017/RJ-2017-024.

Chapter 13: Two-way analysis of variance

This file replicates the analyses from Chapter 13: Two-way analysis of variance.

First, load the packages that will be needed for this document:

```
library(mosaic)
library(readr)
```

Section 13.1: The two-way ANOVA model

```
HRTRATE <- read_csv("https://nhorton.people.amherst.edu/ips9/data/chapter13/EG13-08HRTRATE.csv")
head(HRTRATE)
```

```
## # A tibble: 6 x 3
##   Sex    Control Runners
##   <chr>    <dbl>   <dbl>
## 1 Female     159     119
## 2 Female     183      84
## 3 Female     140      89
## 4 Female     140     119
## 5 Female     125     127
## 6 Female     155     111
```

By default, the `read_csv()` function will output the types of columns, as we see above. To improve readability for future coding, we will suppress the "Parsed with column specification" message by adding `message = FALSE` at the top of the code chunks.

We need to transform the data from wide to tall format using the `gather()` function.

```
HRTRATE_tidy <- HRTRATE %>%
  tidyr::gather(key = Group, value = Heart_Rate, Control, Runners)
head(HRTRATE_tidy)
```

```
## # A tibble: 6 x 3
##   Sex    Group   Heart_Rate
##   <chr>  <chr>        <dbl>
## 1 Female Control        159
## 2 Female Control        183
## 3 Female Control        140
## 4 Female Control        140
## 5 Female Control        125
## 6 Female Control        155
```

```
## Figure 13.4, age 710
favstats(Heart_Rate ~ Sex + Group, data = HRTRATE_tidy)
```

```
##        Sex.Group min  Q1 median  Q3 max    mean       sd   n missing
## 1 Female.Control 105 137    147 160 196 148.000 16.27095 200       0
## 2   Male.Control  77 119    130 142 172 130.000 17.10035 200       0
## 3 Female.Runners  78 106    116 126 164 115.985 15.97154 200       0
## 4   Male.Runners  69  96    103 112 146 103.975 12.49942 200       0
```

```
## Figure 13.5, age 711
lm_HRTRATE <- lm(Heart_Rate ~ Group * Sex, data = HRTRATE_tidy)
msummary(lm_HRTRATE)
```

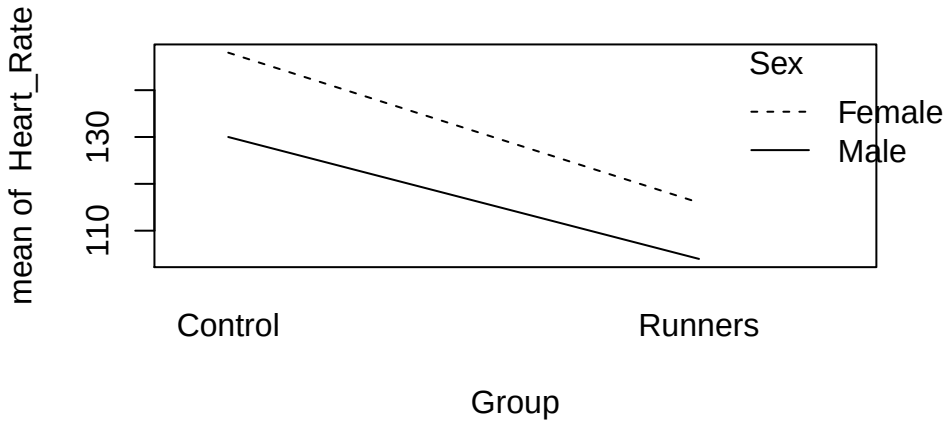
```
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           148.000      1.100 134.511  < 2e-16 ***
## GroupRunners          -32.015      1.556 -20.575  < 2e-16 ***
## SexMale               -18.000      1.556 -11.568  < 2e-16 ***
## GroupRunners:SexMale    5.990      2.201   2.722  0.00663 **
##
## Residual standard error: 15.56 on 796 degrees of freedom
## Multiple R-squared:  0.5276, Adjusted R-squared:  0.5258
## F-statistic: 296.3 on 3 and 796 DF,  p-value: < 2.2e-16
```

```
anova(lm_HRTRATE)
```

```
## Analysis of Variance Table
##
## Response: Heart_Rate
##            Df Sum Sq Mean Sq  F value  Pr(>F)
## Group       1 168432  168432 695.6470 < 2e-16 ***
## Sex         1  45030   45030 185.9799 < 2e-16 ***
## Group:Sex   1   1794    1794   7.4095 0.00663 **
## Residuals 796 192730     242
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

We see that there is a significant interaction (p=0.007): the sex difference between the heart rates differs by groups.

```
### Figure 13.6, page 712
with(HRTRATE_tidy, interaction.plot(Group, Sex, Heart_Rate))
```



Section 13.2: Inference for two-way ANOVA