IS5 in R: Relationships Between Categorical Variables–Contingency Tables (Chapter 3)

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Introduction and background

This document is intended to help describe how to undertake analyses introduced as examples in the Fifth Edition of *Intro Stats* (2018) by De Veaux, Velleman, and Bock. More information about the book can be found at http://wps.aw.com/aw_deveaux_stats_series. This file as well as the associated R Markdown reproducible analysis source file used to create it can be found at http://nhorton.people.amherst.edu/is5.

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 3: Relationships Between Categorical Variables–Contingency Tables

Section 3.1: Contingency Tables

```
library(mosaic)
library(readr)
library(janitor)
OKCupid <-
  read_csv("http://nhorton.people.amherst.edu/is5/data/OKCupid_CatsDogs.csv", skip = 1) %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   CatsDogsBoth = col_character(),
##   Gender = col_character(),
##   `drugsY/N` = col_character(),
##   `smokesY/N` = col_character()
## )
```

```
names(OKCupid)
```

```
## [1] "cats_dogs_both" "gender"         "drugs_y_n"      "smokes_y_n"
```

By default, `read_csv()` prints the variable names. These messages can be suppressed using the `message=FALSE` code chunk option to save space and improve readability.
Here we use the `clean_names()` function from the `janitor` package to sanitize the names of the columns (which would otherwise contain special characters or whitespace). You can use the `names()` function to check the cleaned names.
We use `skip = 1` because the first line in the original data set is `Col1`, `Col2`, etc.

```
# Table 3.1, page 65
tally(~ cats_dogs_both + gender, margin = TRUE, useNA = "no", data = OKCupid)
```

```
##               gender
## cats_dogs_both    F    M Total
##       Has Both  897  577  1474
##       Has cats 3412 2388  5800
##       Has dogs 3431 3587  7018
##       Total    7740 6552 14292
```

```
# Table 3.2
tally(~ cats_dogs_both + gender, format = "percent", margin = TRUE, useNA = "no",
      data = OKCupid)
```

```
##               gender
## cats_dogs_both         F         M     Total
##       Has Both  6.276238  4.037224  10.31346
##       Has cats 23.873496 16.708648  40.58214
##       Has dogs 24.006437 25.097957  49.10439
##       Total    54.156171 45.843829 100.00000
```

```
tally(cats_dogs_both ~ gender, format = "percent", margin = TRUE, useNA = "no",
      data = OKCupid)
```

```
##               gender
## cats_dogs_both         F         M
##       Has Both 11.589147  8.806471
##       Has cats 44.082687 36.446886
##       Has dogs 44.328165 54.746642
##       Total    100.00000 100.00000
```

```
# Table 3.3
tally(gender ~ cats_dogs_both, format = "percent", margin = TRUE, data = OKCupid)
```

```
##        cats_dogs_both
## gender   Has Both  Has cats  Has dogs      <NA>
##   F      60.85482  58.82759  48.88857  35.87435
##   M      39.14518  41.17241  51.11143  64.12565
##   Total 100.00000 100.00000 100.00000 100.00000
```

Example 3.1: Exploring Marginal Distributions

```
SuperBowl <-
  read_csv("http://nhorton.people.amherst.edu/is5/data/Watch_the_Super_bowl.csv",
           skip = 1)
```

```
## Parsed with column specification:
## cols(
##   Plan = col_character(),
##   Sex = col_character()
## )
```

```
tally(~ Plan + Sex, data = SuperBowl)
```

```
##             Sex
## Plan         Female Male
##   Commercials    156   81
```

```
##   Game           200  279
##   Wont Watch     160  132
```

Example 3.2: Exploring Percentages: Children and First-Class Ticket Holders First?

```
Titanic <- read_csv("http://nhorton.people.amherst.edu/is5/data/Titanic.csv")
```

```
## Parsed with column specification:
## cols(
##   Name = col_character(),
##   Survived = col_character(),
##   Boarded = col_character(),
##   Class = col_character(),
##   MWC = col_character(),
##   Age = col_double(),
##   Adut_or_Chld = col_character(),
##   Sex = col_character(),
##   Paid = col_double(),
##   Ticket_No = col_character(),
##   Boat_or_Body = col_character(),
##   Job = col_character(),
##   Class_Dept = col_character(),
##   Class_Full = col_character()
## )
```

```
tally(~ Class + Survived, format = "percent", margin = TRUE, data = Titanic)
```

```
##        Survived
## Class        Alive       Dead      Total
##   1       9.103261   5.570652  14.673913
##   2       5.389493   7.518116  12.907609
##   3       8.152174  24.003623  32.155797
##   Crew    9.601449  30.661232  40.262681
##   Total  32.246377  67.753623 100.000000
```

```
tally(Class ~ Survived, format = "percent", margin = TRUE, data = Titanic)
```

```
##        Survived
## Class        Alive       Dead
##   1      28.230337   8.221925
##   2      16.713483  11.096257
##   3      25.280899  35.427807
##   Crew   29.775281  45.254011
##   Total 100.000000 100.000000
```

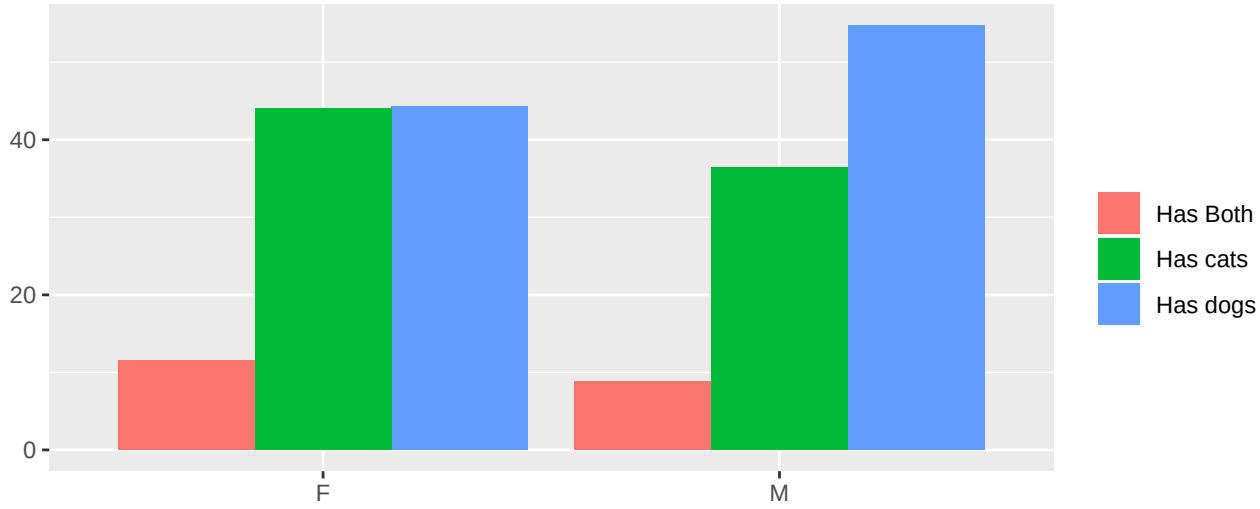
```
tally(Survived ~ Class, format = "percent", margin = TRUE, data = Titanic)
```

```
##         Class
## Survived         1         2         3      Crew
##    Alive  62.03704  41.75439  25.35211  23.84702
##    Dead   37.96296  58.24561  74.64789  76.15298
##    Total 100.00000 100.00000 100.00000 100.00000
```

Section 3.2: Conditional Distributions

See displays on 68-69.

```
OKdata <- tally(cats_dogs_both ~ gender, format = "percent", useNA = "no",
      data = OKCupid) %>%
  data.frame()
# Figure 3.2, page 69
gf_col(Freq ~ gender, fill = ~ cats_dogs_both, position = "dodge", data = OKdata) %>%
  gf_labs(x = "", y = "", fill = "")
```



Example 3.3: Finding Conditional Distributions: Watching the Super Bowl

```
tally(~ Plan + Sex, margin = TRUE, data = SuperBowl)
```

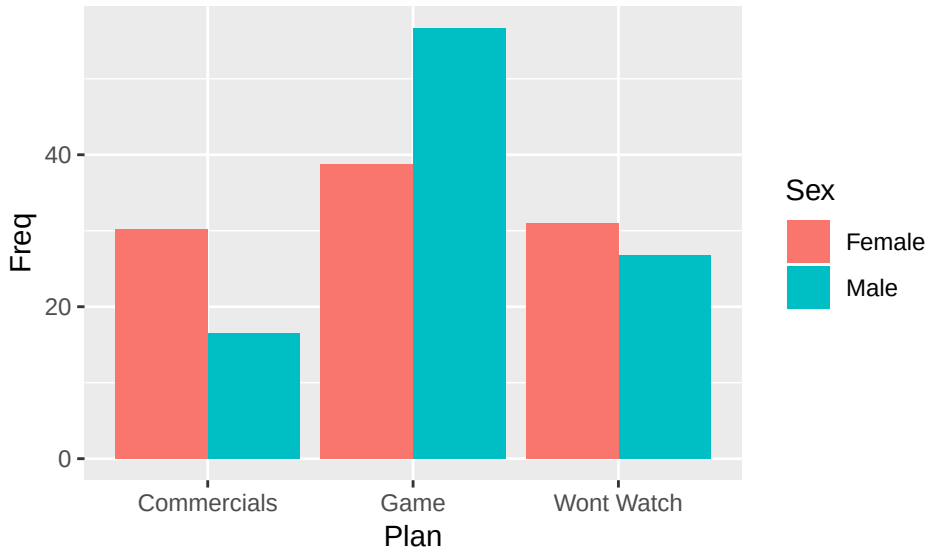
```
##              Sex
## Plan          Female Male Total
##   Commercials    156   81   237
##   Game           200  279   479
##   Wont Watch     160  132   292
##   Total          516  492  1008
```

```
tally(Plan ~ Sex, format = "percent", data = SuperBowl)
```

```
##              Sex
## Plan            Female     Male
##   Commercials 30.23256 16.46341
##   Game        38.75969 56.70732
##   Wont Watch  31.00775 26.82927
```

Example 3.4: Looking for Associations Between Variables: Still Watching the Super Bowl

```
Superdata <- tally(Plan ~ Sex, format = "percent", data = SuperBowl) %>%
  data.frame()
gf_col(Freq ~ Plan, fill = ~ Sex, position = "dodge", data = Superdata)
```



Examining Contingency Tables

See displays on page 72.

```
FishDiet <- read_csv("http://nhorton.people.amherst.edu/is5/data/Fish_diet.csv", skip = 1) %>%
  clean_names()
```

```
## Parsed with column specification:
## cols(
##   `Diet:Counts` = col_character(),
##   `Cancer:Counts` = col_character()
## )
```

```
tally(~ diet_counts + cancer_counts, margins = TRUE, data = FishDiet)
```

```
##             cancer_counts
## diet_counts   No  Yes Total
##    Large     507   42   549
##    Moderate 2769  209  2978
##    Never     110   14   124
##    Small    2420  201  2621
##    Total    5806  466  6272
```

Random Matters

See display on page 74.

```
Nightmares <- read_csv("http://nhorton.people.amherst.edu/is5/data/Nightmares.csv", skip = 1)
```

```
## Parsed with column specification:
## cols(
##   Side = col_character(),
##   Dream = col_character()
## )
```

```
Nightmares <- Nightmares %>%
  mutate(Dream = ifelse(Dream == "N", "Nightmare", "SweetDreams"))
tally(~ Dream + Side, margins = TRUE, data = Nightmares)
```

```
##              Side
## Dream          L  R Total
##   Nightmare    9  6    15
##   SweetDreams 13 35    48
##   Total       22 41    63
```

Section 3.3: Displaying Contingency Tables

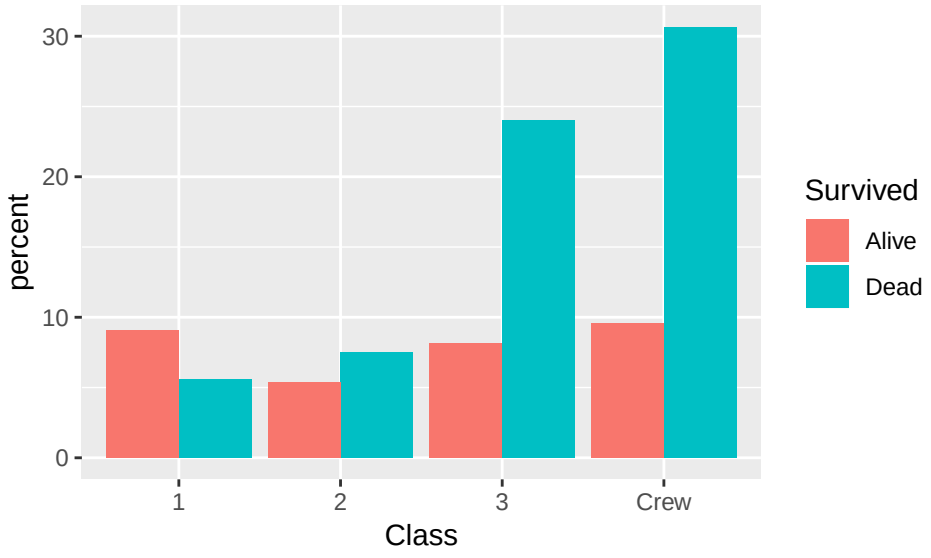
```
tally(~ Class + Survived, format = "count", data = Titanic)
```

```
##       Survived
## Class  Alive Dead
##   1      201  123
##   2      119  166
##   3      180  530
##   Crew   212  677
```

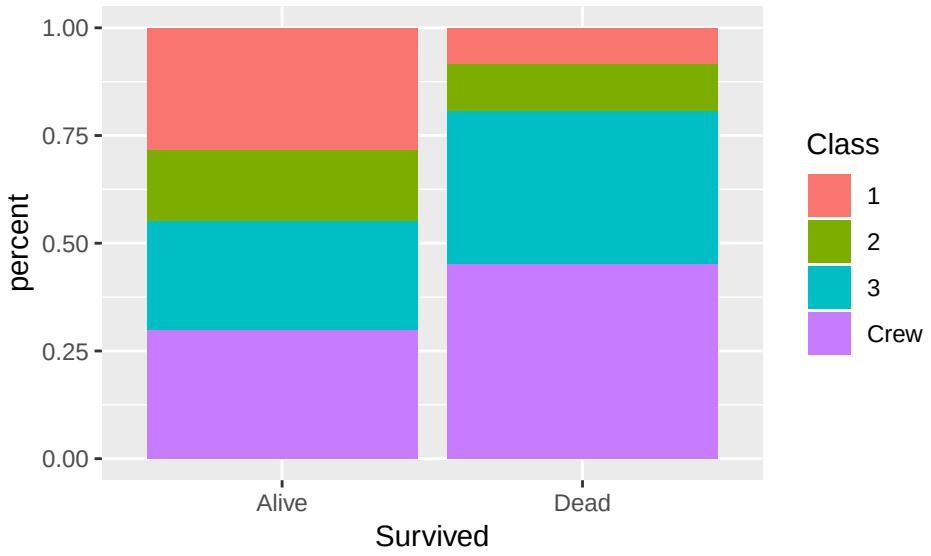
```
tally(~ Class + Survived, format = "percent", data = Titanic)
```

```
##       Survived
## Class      Alive      Dead
##   1     9.103261  5.570652
##   2     5.389493  7.518116
##   3     8.152174 24.003623
##   Crew  9.601449 30.661232
```

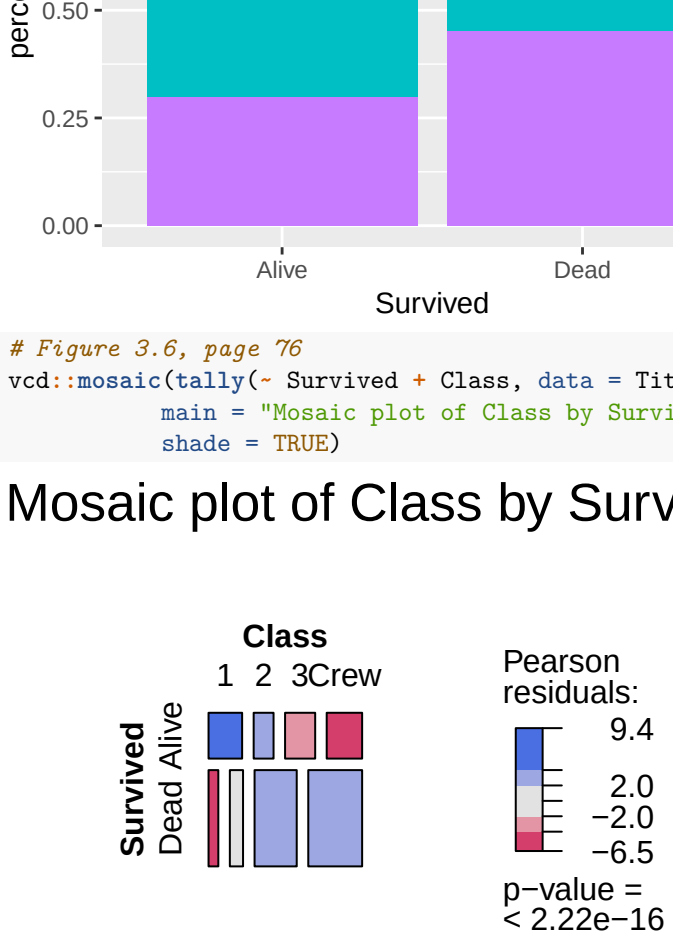
```
# Figure 3.4, page 75
gf_percents(~ Class, fill = ~ Survived, position = position_dodge(), data = Titanic)
```




```
# Figure 3.5
gf_percents(~ Survived, fill = ~ Class, position = "fill", data = Titanic)
```




```
# Figure 3.6, page 76
vcd::mosaic(tally(~ Survived + Class, data = Titanic),
            main = "Mosaic plot of Class by Survival",
            shade = TRUE)
```



See the mosaic plots on page 77.

Section 3.4: Three Categorical Variables

Consider using `useNA = "no"` option

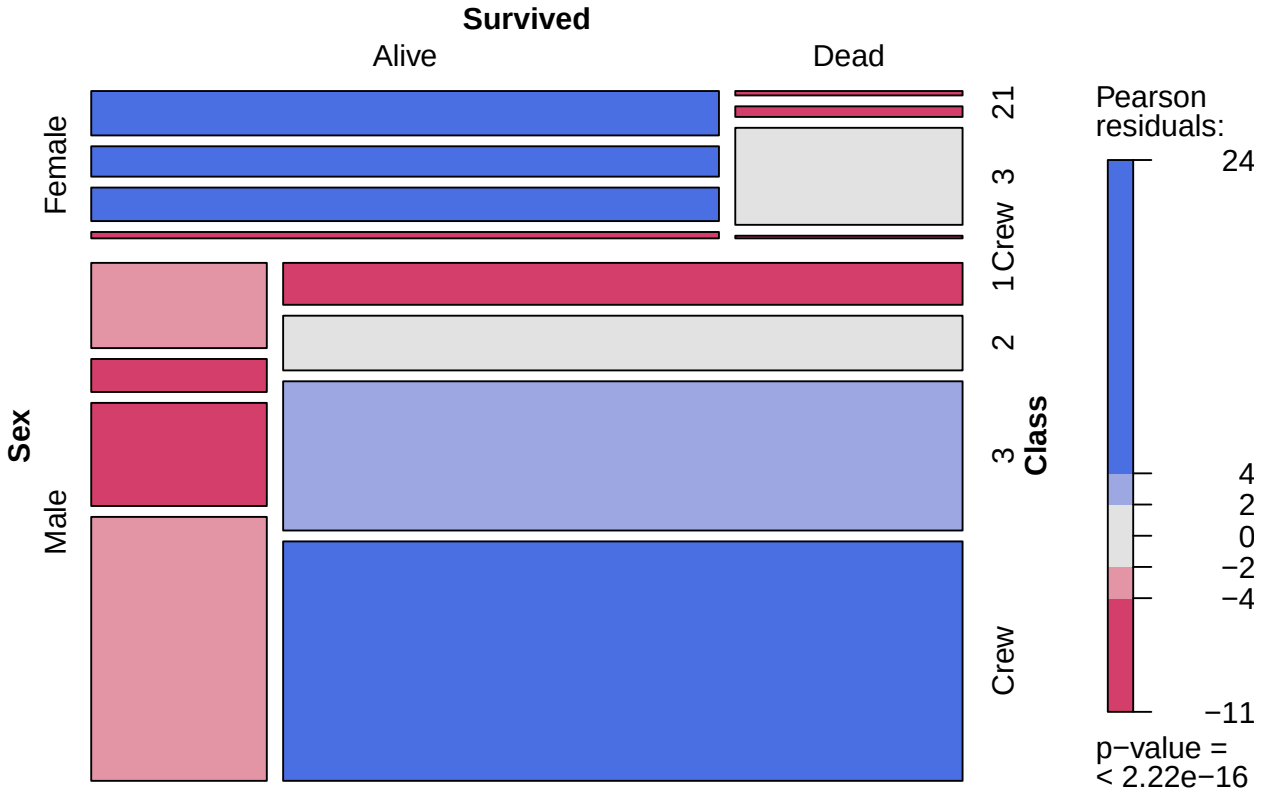
```
tally(~ gender + cats_dogs_both + drugs_y_n, format = "percent", data = OKCupid)
```

```
## , , drugs_y_n = No
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  1.0243064  3.4199156  3.9437466 18.0187845
##      M  0.5922293  2.0819779  3.7769214 30.0719016
##
```

```
## , , drugs_y_n = Yes
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  0.2085314  0.8941828  0.6272626  2.9794972
##      M  0.1901807  0.8658225  0.9041923  6.9132342
##
## , , drugs_y_n = NA
##
##       cats_dogs_both
## gender   Has Both   Has cats   Has dogs       <NA>
##      F  0.2635837  1.3779757  1.1527618  6.3226732
##      M  0.1801712  1.0359842  1.3029044 11.8512587
```

Example 3.7: Looking for Associations Among Three Variables at Once

```
vcd::mosaic(tally(~ Sex + Survived + Class, data = Titanic), shade = TRUE)
```



Example 3.8: Simpson's Paradox: Gender Discrimination?

Here we demonstrate how to generate one of the tables on page 80.

```
# Create a dataframe from the counts
# http://mathemathinking.blogspot.com/2012/06/simpsons-paradox.html
Berk <- rbind(
  do(512) *       data.frame(admit = TRUE,  sex = "M", school = "A"),
  do(825 - 512) * data.frame(admit = FALSE, sex = "M", school = "A"),
  do(89) *        data.frame(admit = TRUE,  sex = "F", school = "A"),
```

```
  do(19) *        data.frame(admit = FALSE, sex = "F", school = "A")
)
```

In this case, `do(n)` creates `n` observations with the specified values in `data.frame()`. The `rbind()` function can then be used to combine the data frames into one.

```
tally(~ sex + admit, data = Berk)
```

```
##    admit
## sex TRUE FALSE
##   M  512   313
##   F   89    19
```

```
tally(admit ~ sex, format = "percent", data = Berk)
```

```
##        sex
## admit          M        F
##   TRUE  62.06061 82.40741
##   FALSE 37.93939 17.59259
```