

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.

```
tally(~ cats_dogs_both + gender, margin = TRUE, data = OKCupid)
```

```
##               gender
## cats_dogs_both   F     M Total
##   Has Both    897   577 1474
##   Has cats    3412  2388 5800
##   Has dogs    3431  3587 7018
##   <NA>        16377 29274 45651
##   Total      24117 35826 59943
```

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

```
##               gender
## cats_dogs_both   F     M     Total
##   Has Both    1.4964216 0.9625811 2.4590027
##   Has cats    5.6920741 3.9837846 9.6758587
##   Has dogs    5.7237709 5.9840182 11.7077891
##   <NA>        27.3209549 48.8363946 76.1573495
##   Total      40.2332216 59.7667784 100.0000000
```

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

```
##               gender
## cats_dogs_both   F     M
##   Has Both    3.719368 1.610562
##   Has cats   14.147697 6.665550
##   Has dogs   14.226479 10.012282
##   <NA>       67.906456 81.711606
##   Total     100.000000 100.000000
```

```
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(~ 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
```

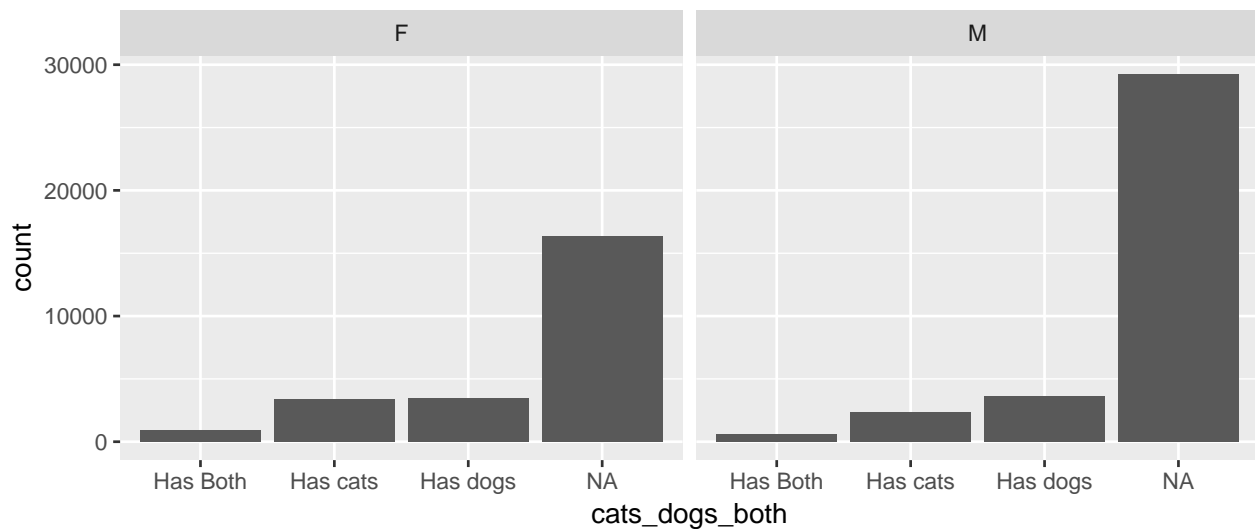
```
tally(~ Class | Survived, format = "percent", margin = TRUE, data = Titanic)
```

```
##           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
```

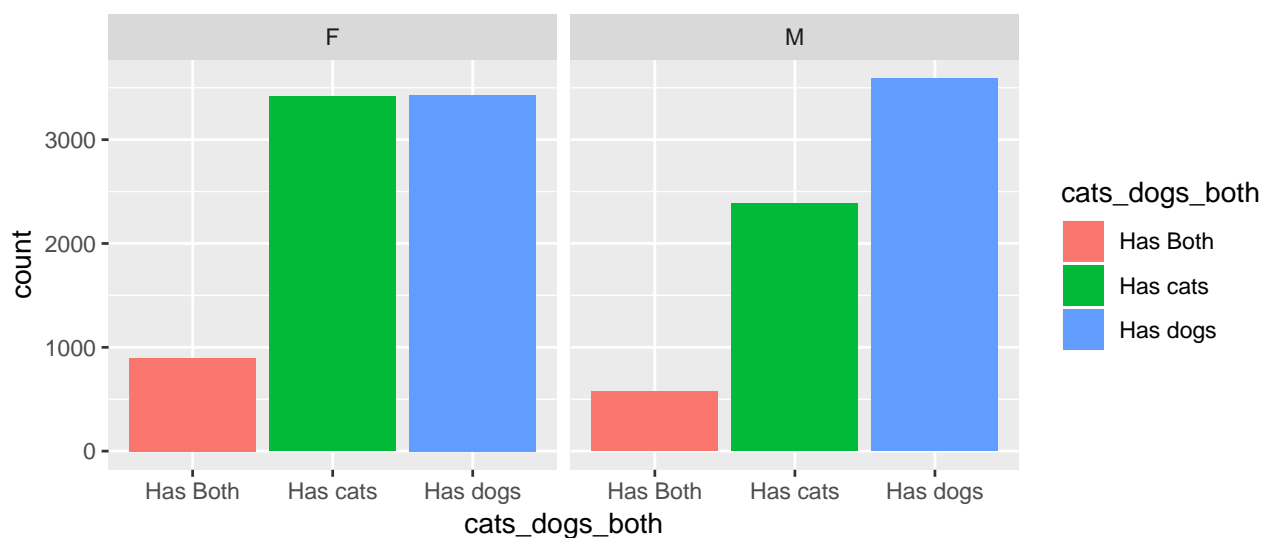
Section 3.2: Conditional Distributions

See displays on 68-69.

```
gf_bar(~ cats_dogs_both | gender, data = OKCupid)
```



```
# There are many who don't own either (Figure 3.2, page 69)
gf_bar(~ cats_dogs_both | gender, fill = ~ cats_dogs_both,
  data = filter(OKCupid, cats_dogs_both != "NA"))
```



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
```

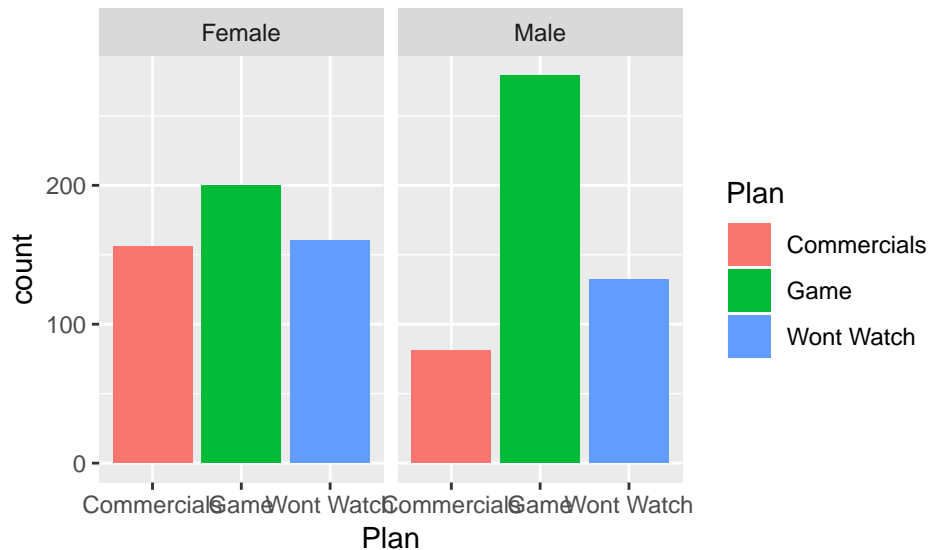
```
tally(~ Plan | Sex, format = "percent", data = SuperBowl)
```

```
##           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

```
gf_bar(~ Plan | Sex, fill = ~ Plan, format = "percent", data = SuperBowl)
```



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, data = FishDiet)
```

```
##           cancer_counts
## diet_counts  No  Yes
## Large       507  42
## Moderate    2769 209
## Never       110  14
## Small      2420 201
```

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(~ Side + Dream, data = Nightmares)

##      Dream
## Side Nightmare SweetDreams
##    L          9          13
##    R          6          35
```

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)
```

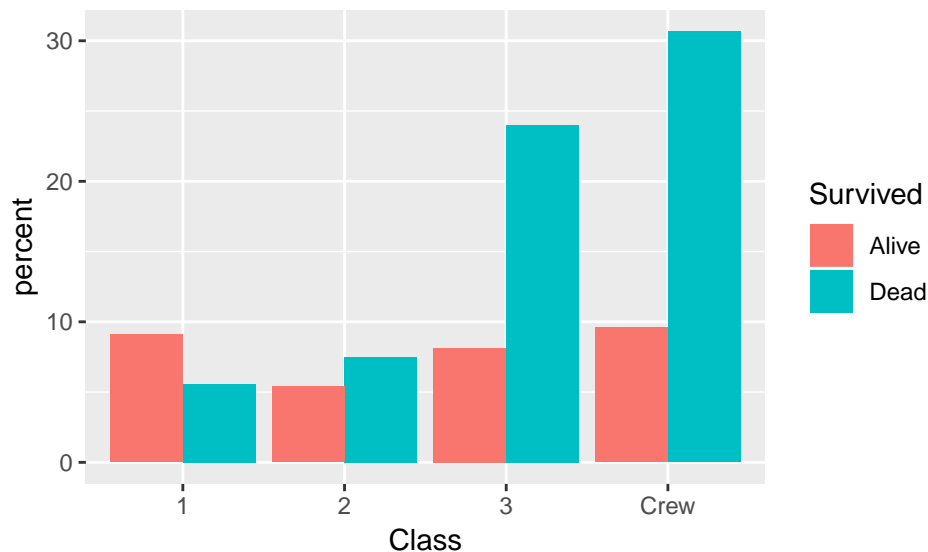
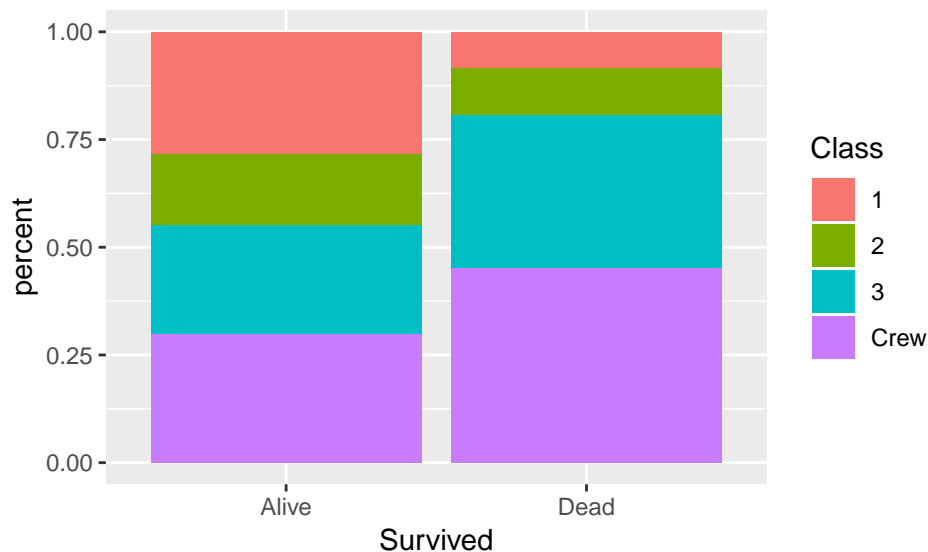


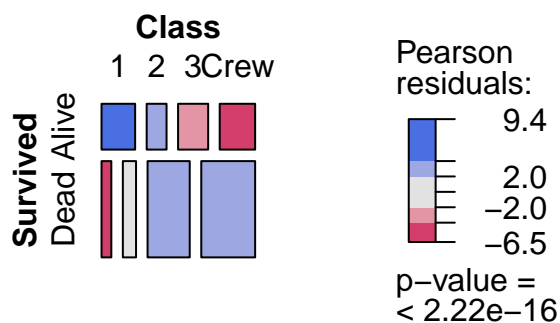
Figure 3.5

```
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)
```

Mosaic plot of Class by Survival



See the mosaic plots on page 77.

Section 3.4: Three Categorical Variables

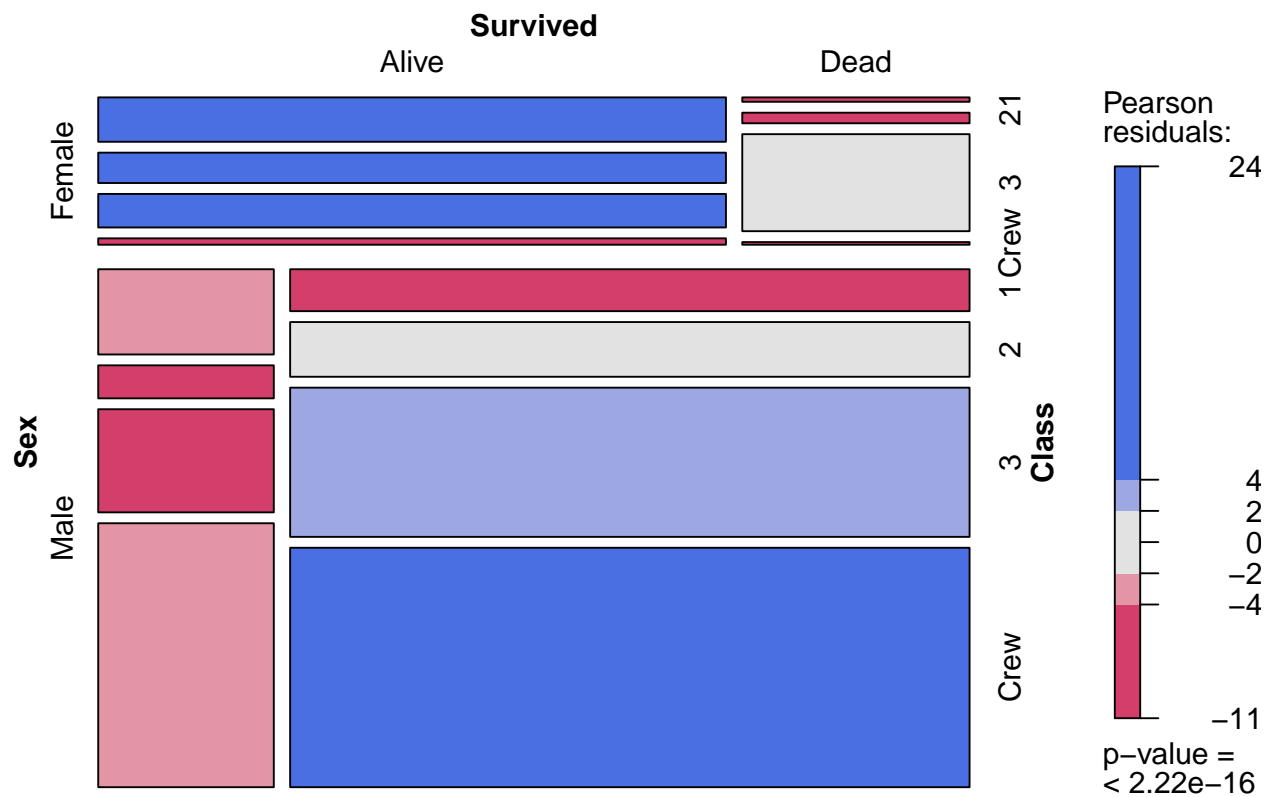
```
tally(~ gender + cats_dogs_both + drugs_y_n, format = "percent", data = OKCupid)

## , , 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
```