IPS9 in R: Probability: The Study of Randomness (Chapter 4)

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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 4: Probability: The Study of Randomness

This file replicates the analyses from Chapter 4: Probability: The Study of Randomness.

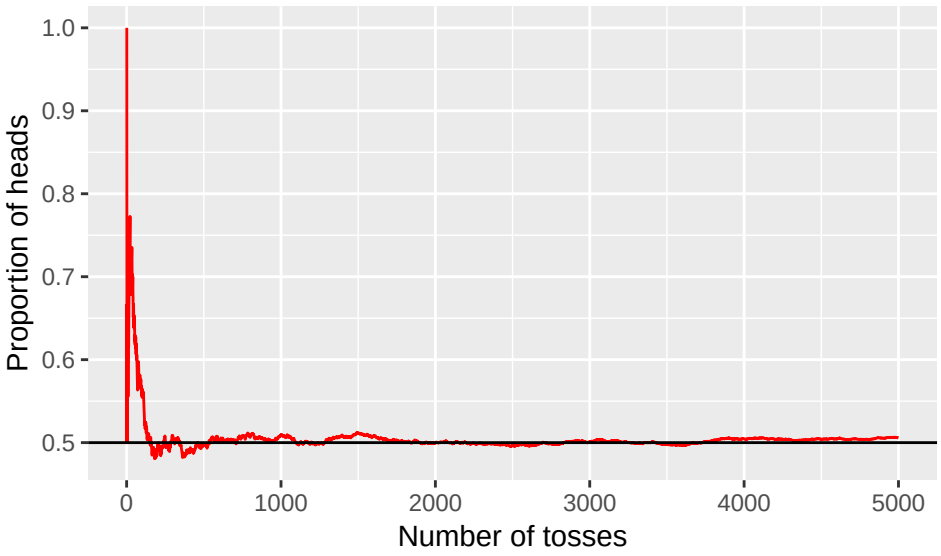
First, load the package that will be needed for this document:

```
library(mosaic)
```

Section 4.1: Randomness

The results of two trials of a coin toss simulation 5000 times are plotted as the proportion of heads, as shown in Figure 3.1 (page 216). We can emulate one trial of such simulation as a plot by typing:

```
tosses <- rbinom(n = 1:5000, size = 1, prob = 0.5)
x <- seq(1:5000)
cy <- cumsum(tosses)
phead <- (cy / x)
gf_line(phead ~ x, color = "red") %>%
  gf_labs(x = "Number of tosses", y = "Proportion of heads") %>%
  gf_hline(., yintercept = 0.5)
```



The parameters in the `rbinom()` function can be explained in the following way: n = 1:5000 specifies the number of observations, while size = 1 specifies the number of trials, with each trial getting a probability of success equal to 0.5. Another way to think about this is: Draw either 0 or 1, given there is a 50% chance of selecting either number, 5000 times.

Another useful function that is related to this xpbinom(), which can be used to plot the proab

The R function, `runif()`, generates a random number between 0 and 1. We can demonstrate using the code below:

```
runif(1)
```

```
## [1] 0.7743532
```

Since the default arguments in the function define the sample space to be all numbers between 0 and 1, all we need to specify the number of random numbers we want outputted. Run the code above several times. Notice that every iteration gives you a different output. If you do not set a seed, every time you run the code, you will get a random number.

To demonstrate adjustments that you can make to the `runif()` call:

```
runif(2) #change the number of random numbers generated from this sample space
```

```
## [1] 0.4256979 0.3871379
```

```
set.seed(2018) #setting the seed to get reproducible results
runif(1)
```

```
## [1] 0.3361535
```

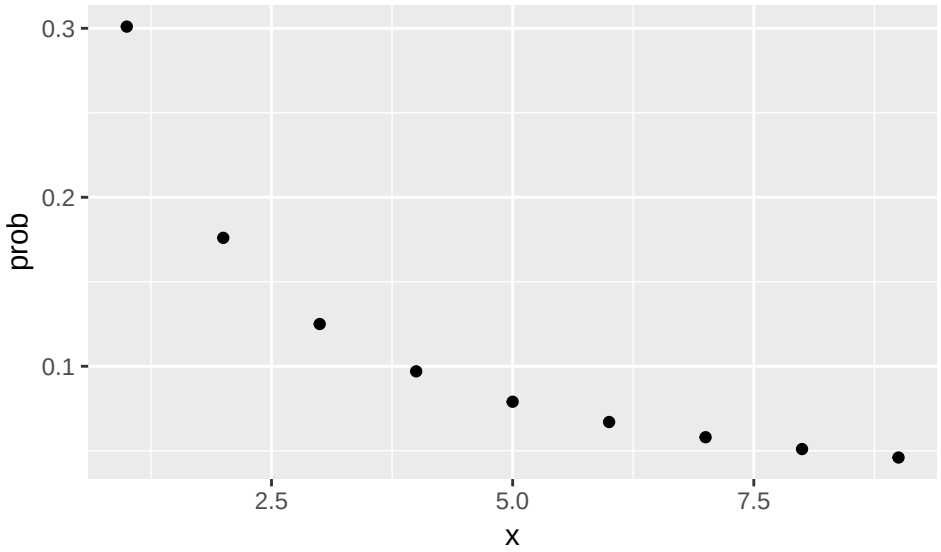
Now that we have selected a pseudorandom seed, anyone who runs this code should expect to see the output of `runif(1)` to be 0.34.

Section 4.2: Probability models

Section 4.3: Random variables

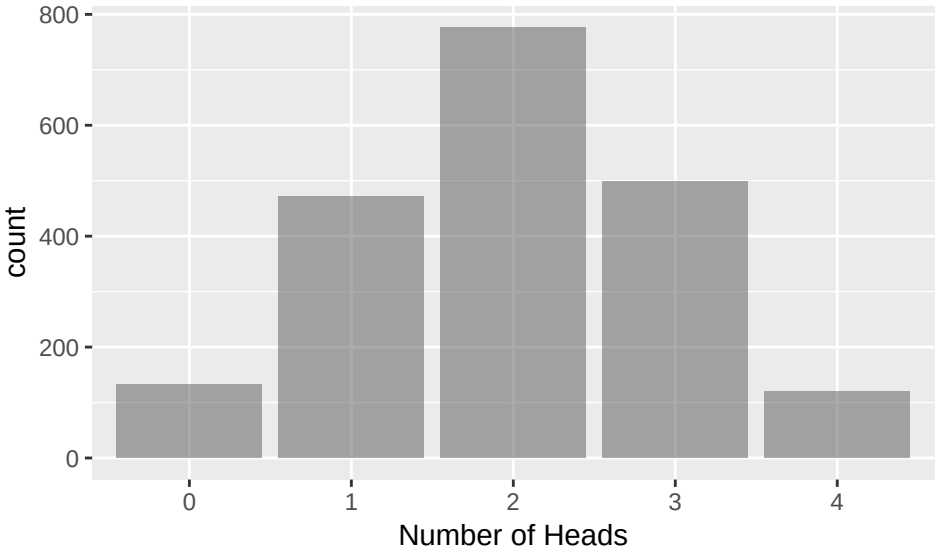
We can also display probability histograms that compare the probability model for equally likely random digits with the model given by Benford's law (page 237):

```r
# Figure 4.5 (a)
eq_likely <- data.frame(Outcomes = rbinom(1000, 1:9, 0.111))
# Figure 4.5 (b)
benlaw <- c(0.301, 0.176, 0.125, 0.097, 0.079, 0.067, 0.058, 0.051, 0.046)
digits <- 1:9
bendata <- data.frame(prob = benlaw, x = digits)
gf_point(prob ~ x, data = bendata)
```



Below is the code to generate a probability histogram for the distribution of the number of heads in 2000 trials of tossing a coin four times as shown in Figure 4.7 (page 239):

```r
trials <- data.frame(Heads = rbinom(2000, size = 4, prob = 0.5))
gf_histogram(~ as.factor(Heads), data = trials, stat = "count") %>%
  gf_labs(x = "Number of Heads")
```



Section 4.4: Means and variances of random variables

Section 4.5: General probability rules