FOUNDATIONS OF PROBABILITY IN R

# Updating from evidence

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# 20 flips of a coin

# Two piles of 50,000 coins

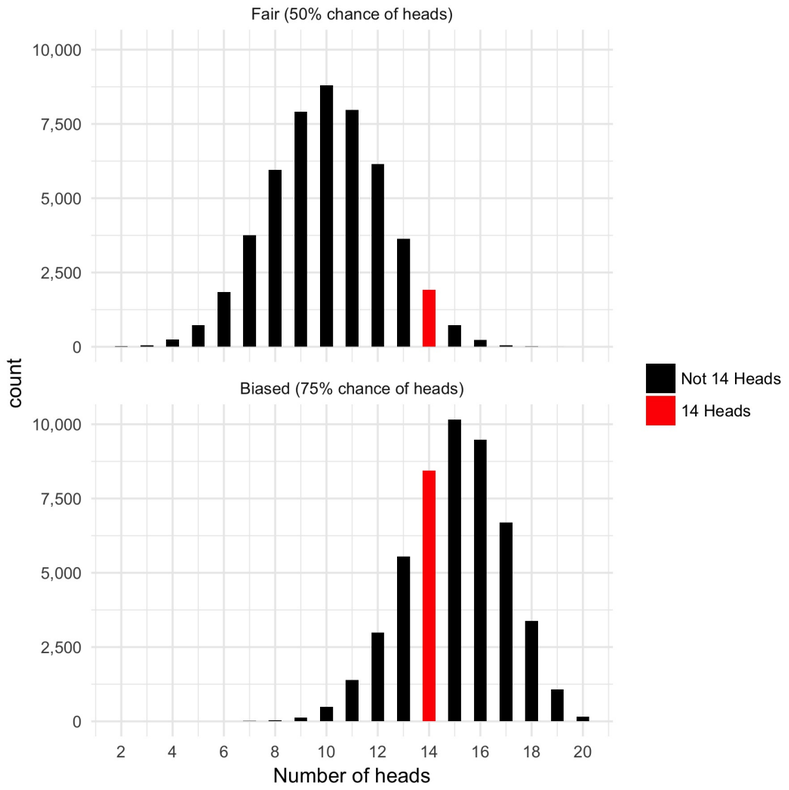
```
fair <- rbinom(50000, 20, .5)
sum(fair == 14)
# 1888
```

```
biased <- rbinom(50000, 20, .75)
sum(biased == 14)
# 8372
```

```
1888 + 8372
# [1] 10260
```

$$\Pr(\text{Biased}|14\text{ Heads}) = \frac{\#\text{ biased w/14 Heads}}{\#\text{ total w/14 Heads}}$$

$$= \frac{8372}{1888 + 8372} = 82\%$$



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# Let's practice!

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# Prior probability

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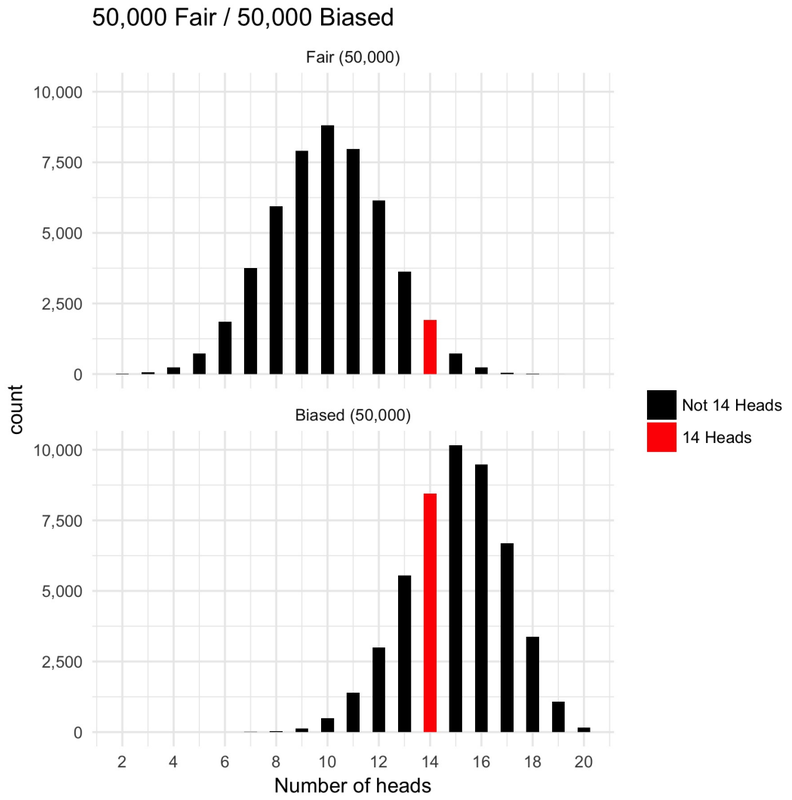
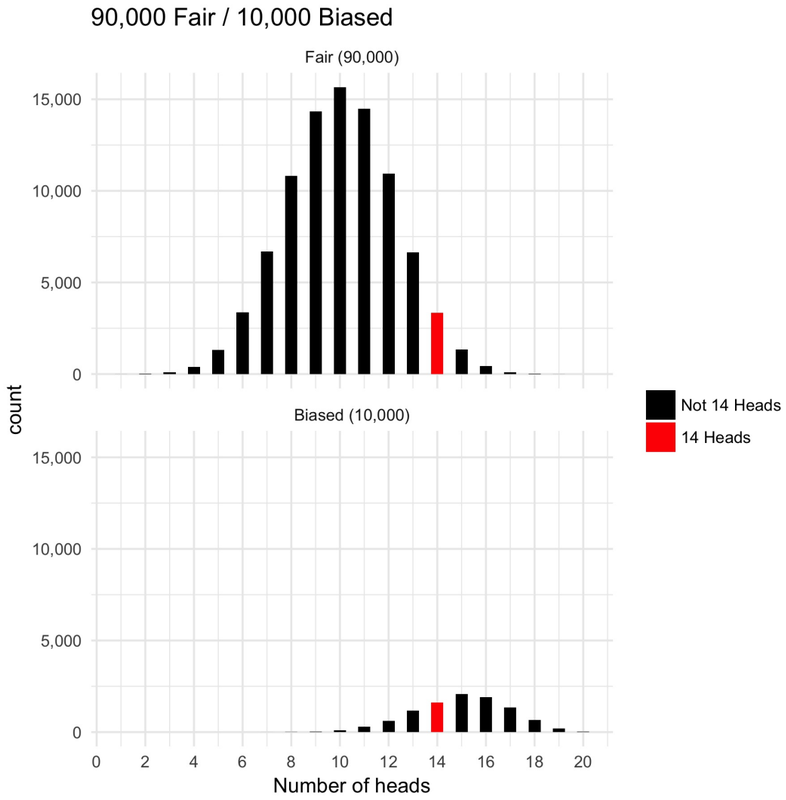
# Differently sized piles



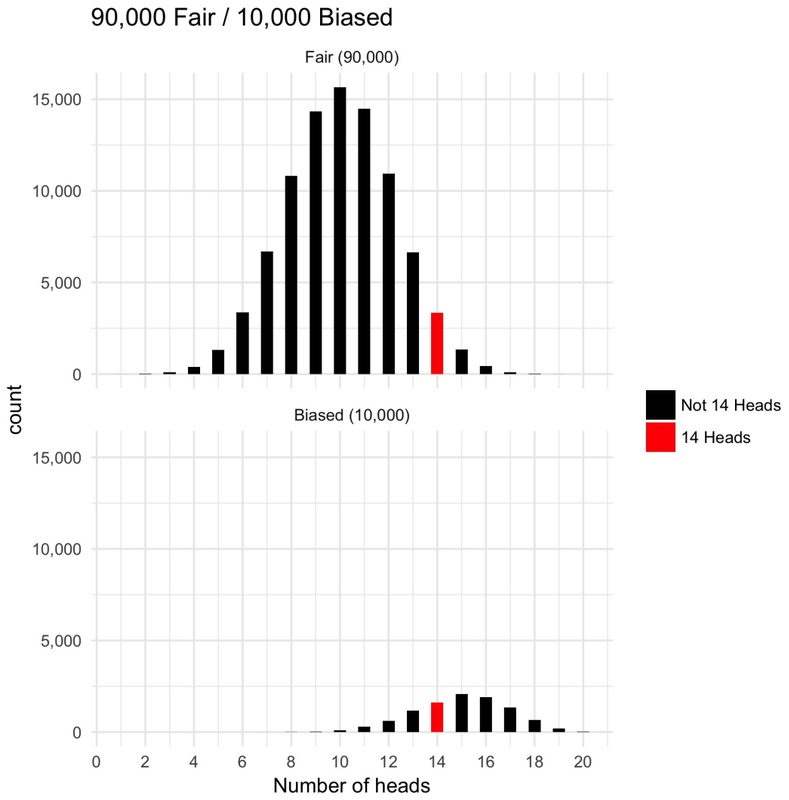
# Simulating with differently sized piles

```
fair <- rbinom(90000, 20, .5)
sum(fair == 14)
# [1] 3410
```

```
biased <- rbinom(10000, 20, .75)
sum(biased == 14)
# [1] 1706
```

$$\frac{\#\text{ of biased w/14 Heads}}{\#\text{ total w/14 Heads}}$$

$$\frac{1706}{1706 + 3410} = .333$$



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# Bayes' theorem

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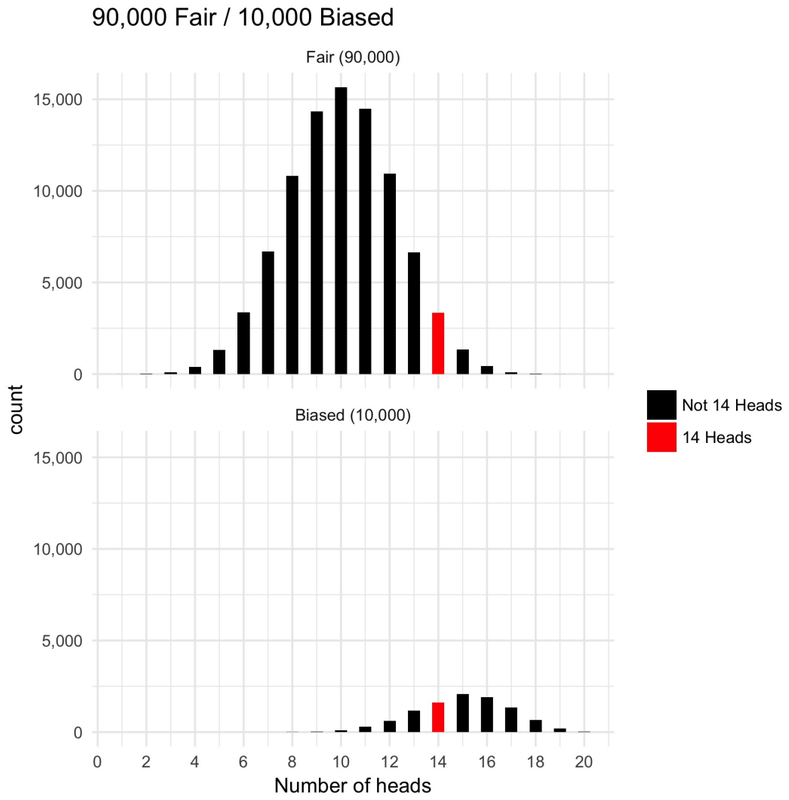
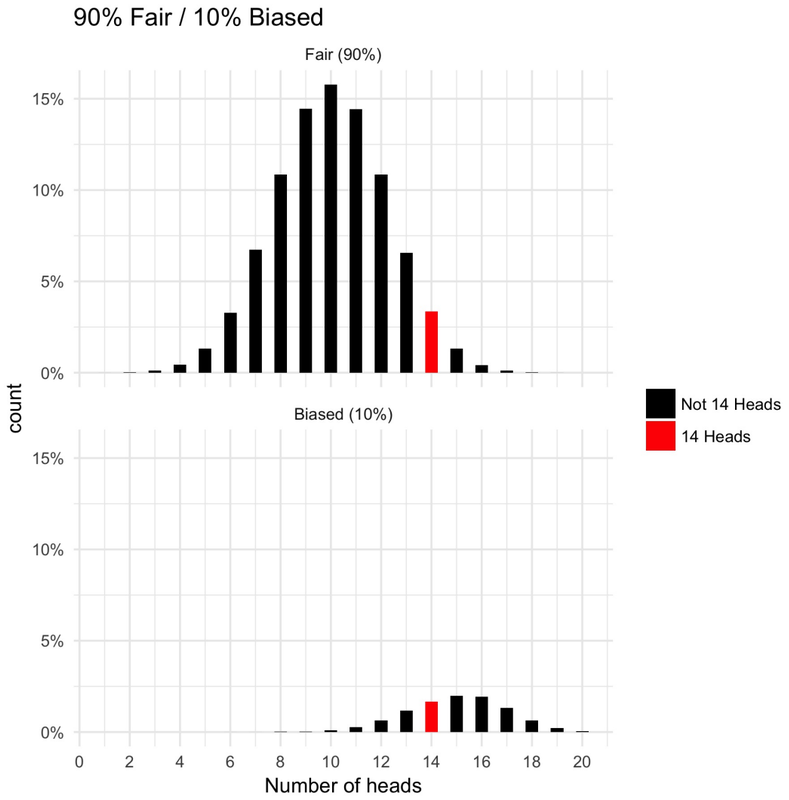
# Probabilities



# Probability of fair coin with 14 heads

```
fair <- rbinom(90000, 20, .5)
sum(fair == 14)
# [1] 3410
```

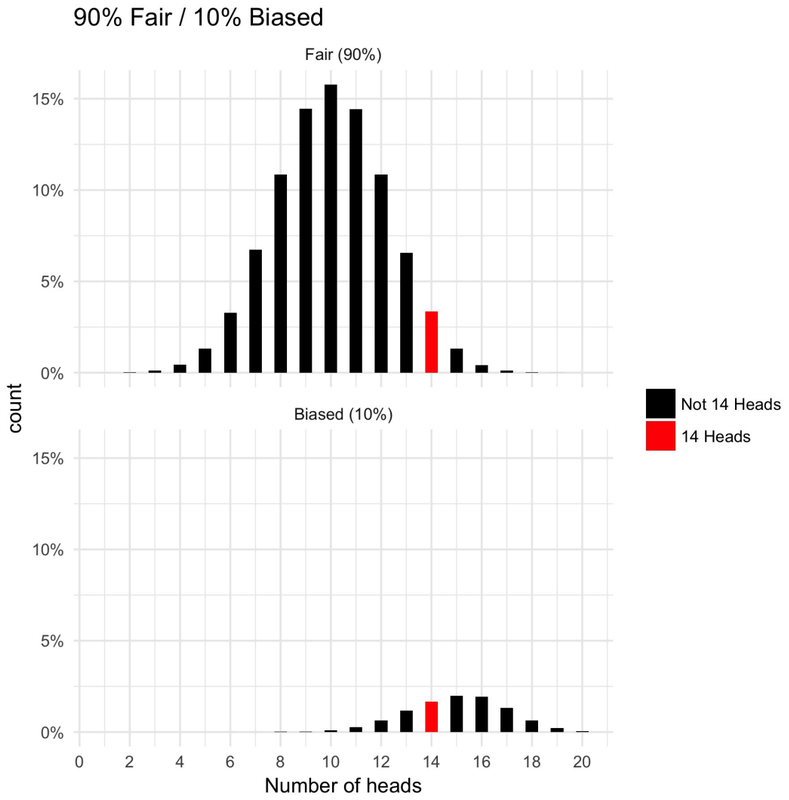
```
dbinom(14, 20, .5) * .9
# [1] 0.03326797
```

$$\Pr(14\ \text{Heads}|\text{Fair}) \cdot \Pr(\text{Fair})$$

```
biased <- rbinom(10000, 20, .75)
sum(biased == 14)
# [1] 1706
```

```
dbinom(14, 20, .75)  * .1
# [1] 0.01686093
```

$$\Pr(14\ \text{Heads}|\text{Biased}) \cdot \Pr(\text{Biased})$$



# Conditional probability

$$\Pr(\text{Biased}|14\text{ Heads}) = \frac{\Pr(14\text{ Heads and Biased})}{\Pr(14\text{ Heads and Biased}) + \Pr(14\text{ Heads and Fair})}$$

$$= \frac{\Pr(14\text{ Heads}|\text{Biased})\Pr(\text{Biased})}{\Pr(14\text{ Heads}|\text{Biased})\Pr(\text{Biased}) + \Pr(14\text{ Heads}|\text{Fair})\Pr(\text{Fair})}$$

```
prob_14_fair <- dbinom(14, 20, .5) * .9
prob_14_biased <- dbinom(14, 20, .75) * .1

prob_14_biased / (prob_14_fair + prob_14_biased)
```

# Bayes' Theorem

$$\Pr(A|B) = \frac{\Pr(B|A)\Pr(A)}{\Pr(B|A)\Pr(A) + \Pr(B|\text{not } A)\Pr(\text{not } A)}$$

$$A = \text{Biased}$$

$$B = 14 \text{ Heads}$$

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