

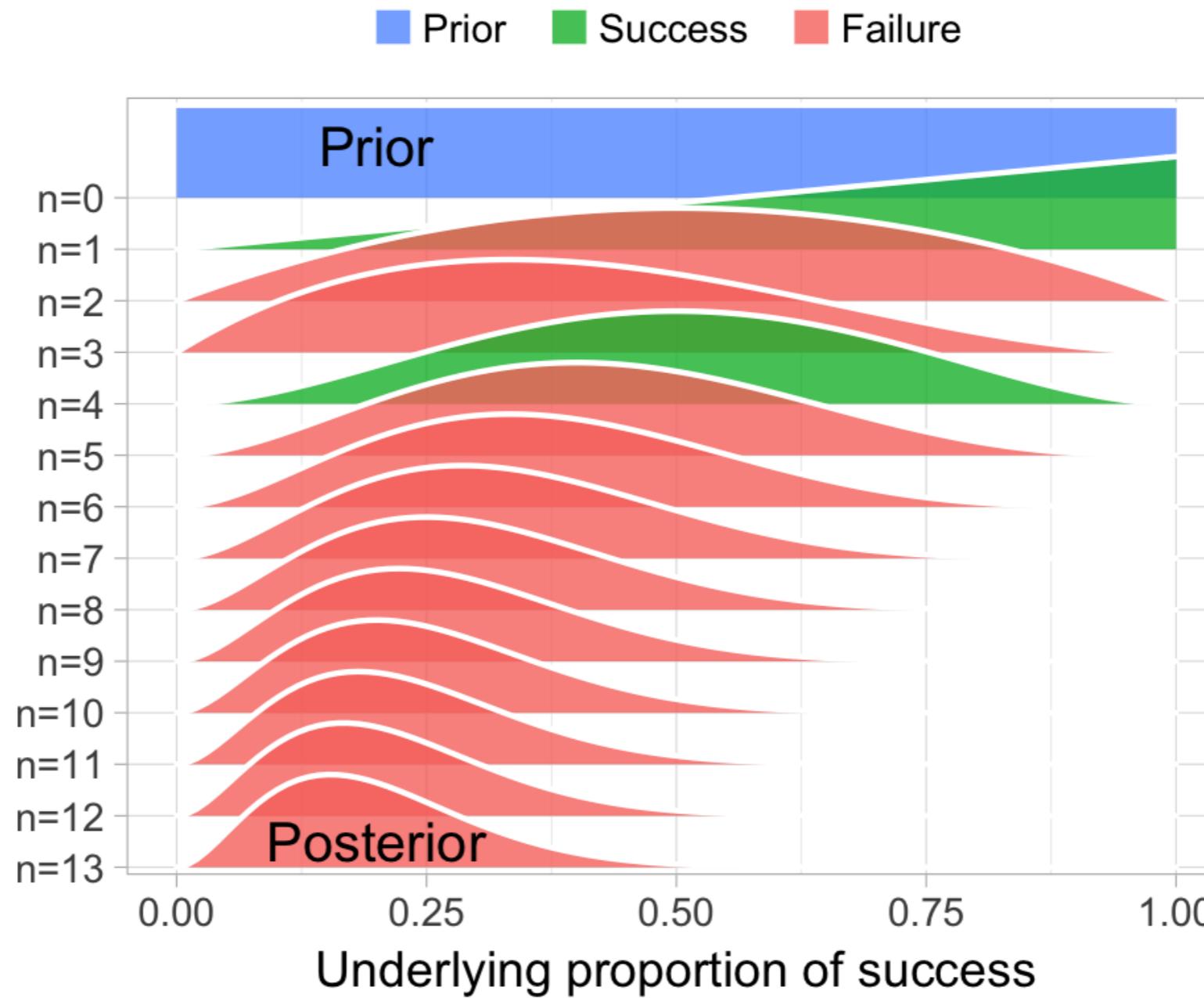
The parts needed for Bayesian inference

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

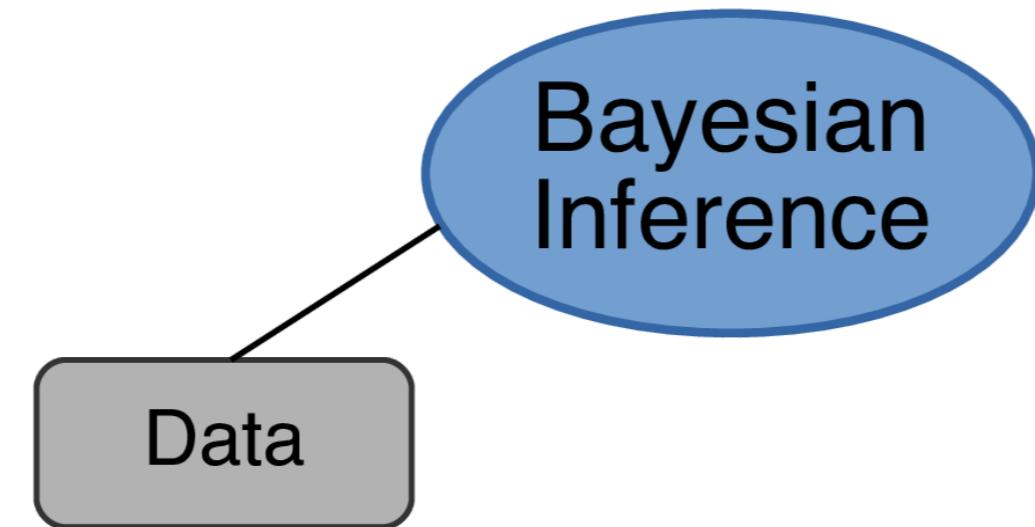


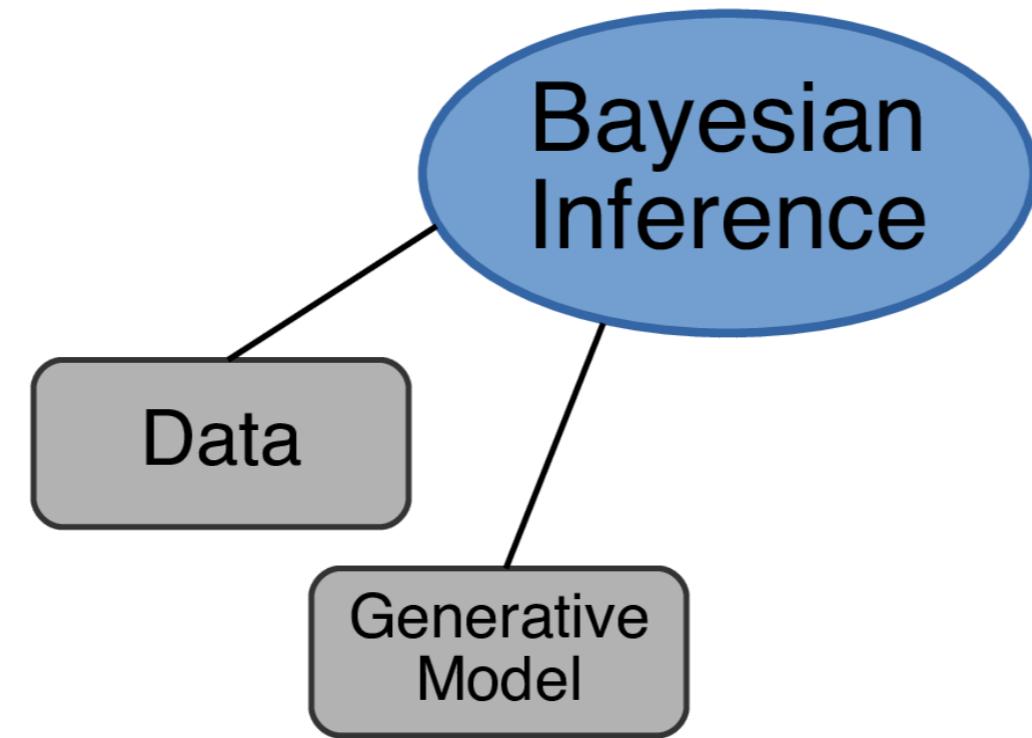
Rasmus Bååth

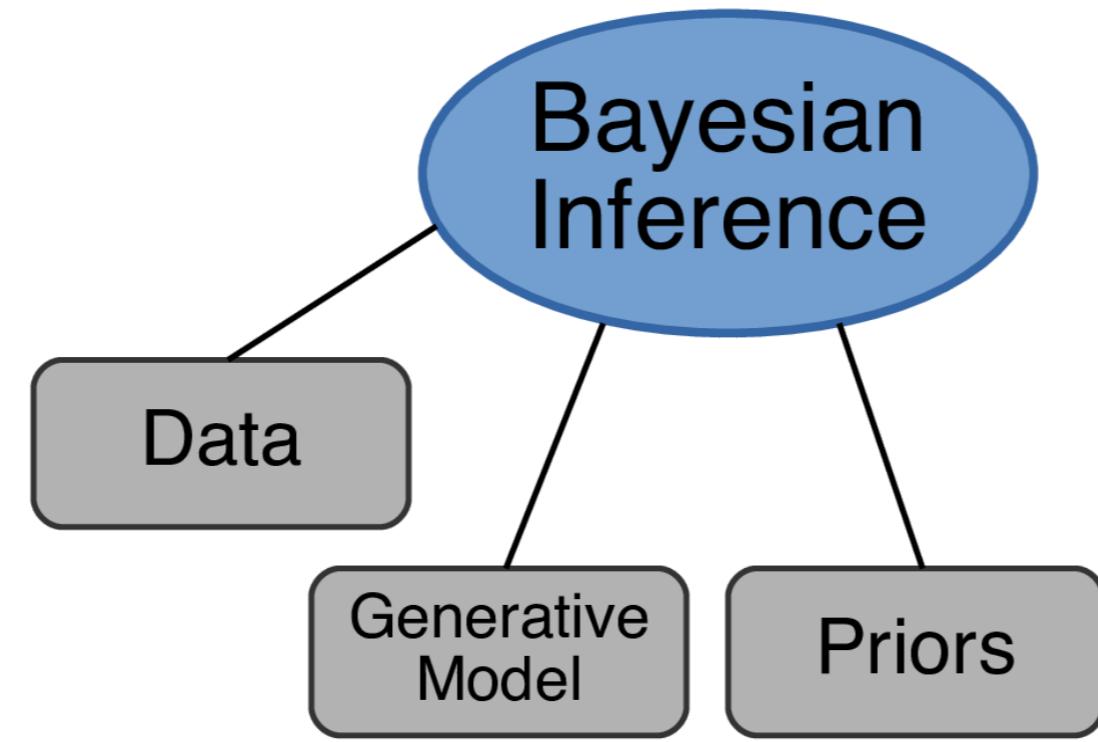
Data Scientist



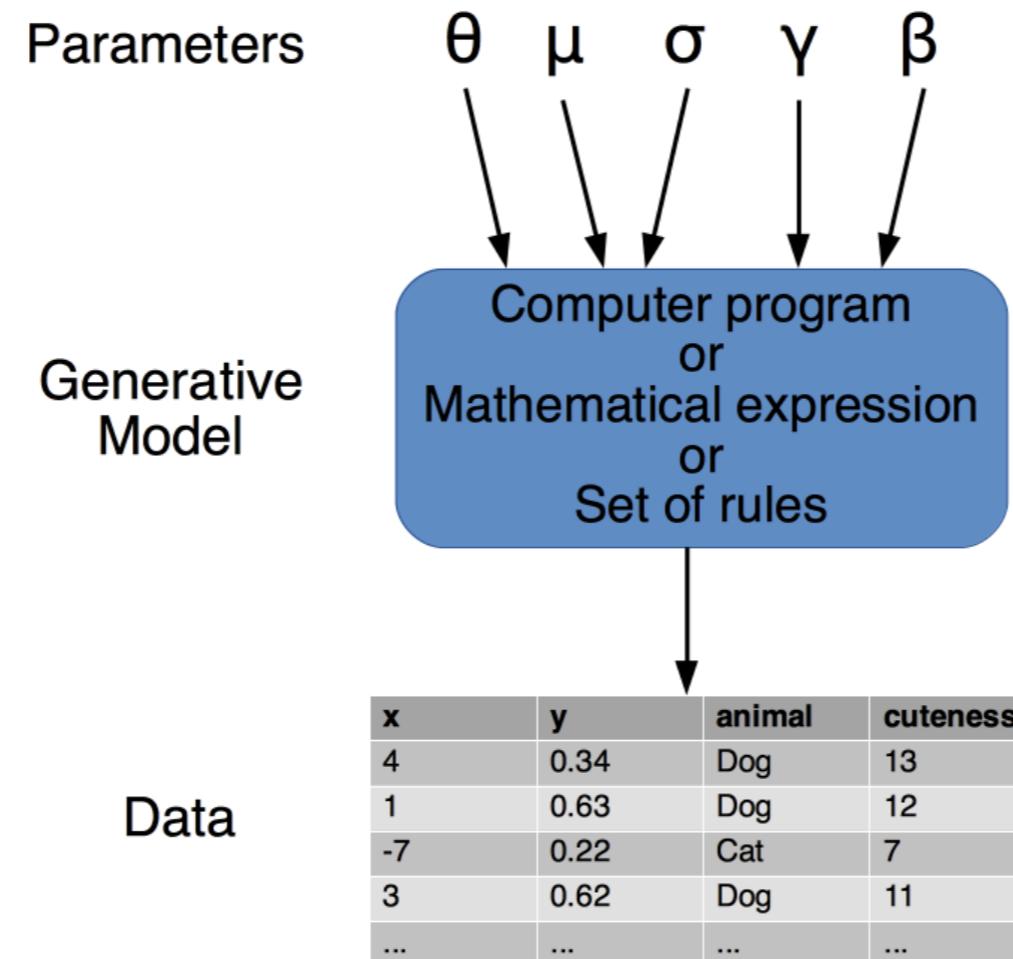
Bayesian
Inference







What is a generative model?



Generative zombie drug model

Generative zombie drug model

```
# Parameters  
prop_success <- ???  
n_zombies <- ???
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
  data[zombie] <- ???  
}  
}
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
  data[zombie] <- runif(1, min = 0, max = 1) < prop_success  
}
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
  data[zombie] <- runif(1, min = 0, max = 1) < prop_success}
```

```
data
```

```
FALSE FALSE FALSE TRUE FALSE FALSE FALSE TRUE FALSE TRUE FALSE FALSE
```

Generative zombie drug model

```
# Parameters
prop_success <- 0.15
n_zombies <- 13
# Simulating data
data <- c()
for(zombie in 1:n_zombies) {
  data[zombie] <- runif(1, min = 0, max = 1) < prop_success
}
data <- as.numeric(data)
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
  data[zombie] <- runif(1, min = 0, max = 1) < prop_success  
}  
data <- as.numeric(data)  
data
```

```
0 0 0 1 0 0 0 0 1 0 1 0 0
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
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}  
data <- as.numeric(data)  
data
```

```
0 0 1 0 0 0 0 0 0 0 0 0
```

Generative zombie drug model

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  data[zombie] <- runif(1, min = 0, max = 1) < prop_success  
}  
data <- as.numeric(data)  
data
```

```
0 1 0 1 1 0 0 1 0 1 0 0 0
```

Generative zombie drug model

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# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
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  data[zombie] <- runif(1, min = 0, max = 1) < prop_success  
}  
data <- as.numeric(data)  
data
```

```
0 0 0 0 0 0 0 1 0 0 0 0 0
```

Generative zombie drug model

```
# Parameters  
prop_success <- 0.15  
n_zombies <- 13  
  
# Simulating data  
data <- c()  
  
for(zombie in 1:n_zombies) {  
  data[zombie] <- runif(1, min = 0, max = 1) < prop_success  
}  
data <- as.numeric(data)  
data
```

```
0 0 0 0 1 0 0 0 0 1 0 1 0
```

**Take this model for a
spin!**

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

Using a generative model

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R



Rasmus Bååth

Data Scientist

```
rbinom(n, size, prob)
```

Generative
Model

rbinom

Parameters prob size



Generative
Model

rbinom

Parameters prob size



Generative
Model

rbinom



Data

34 or 43
or 42 etc.

Parameters prob size



Generative
Model

rbinom



Data

???

Parameters prob size
 7%



Generative
Model

rbinom



Data

???

Parameters prob
 7% size
 100

Generative
Model

rbinom

Data

???



¹ https://commons.wikimedia.org/wiki/File:The_Hoard_III_-_Flickr_-_SoulStealer.co.uk.jpg

```
cured_zombies <- rbinom(n = 100000, size = 100, prob = 0.07)
```

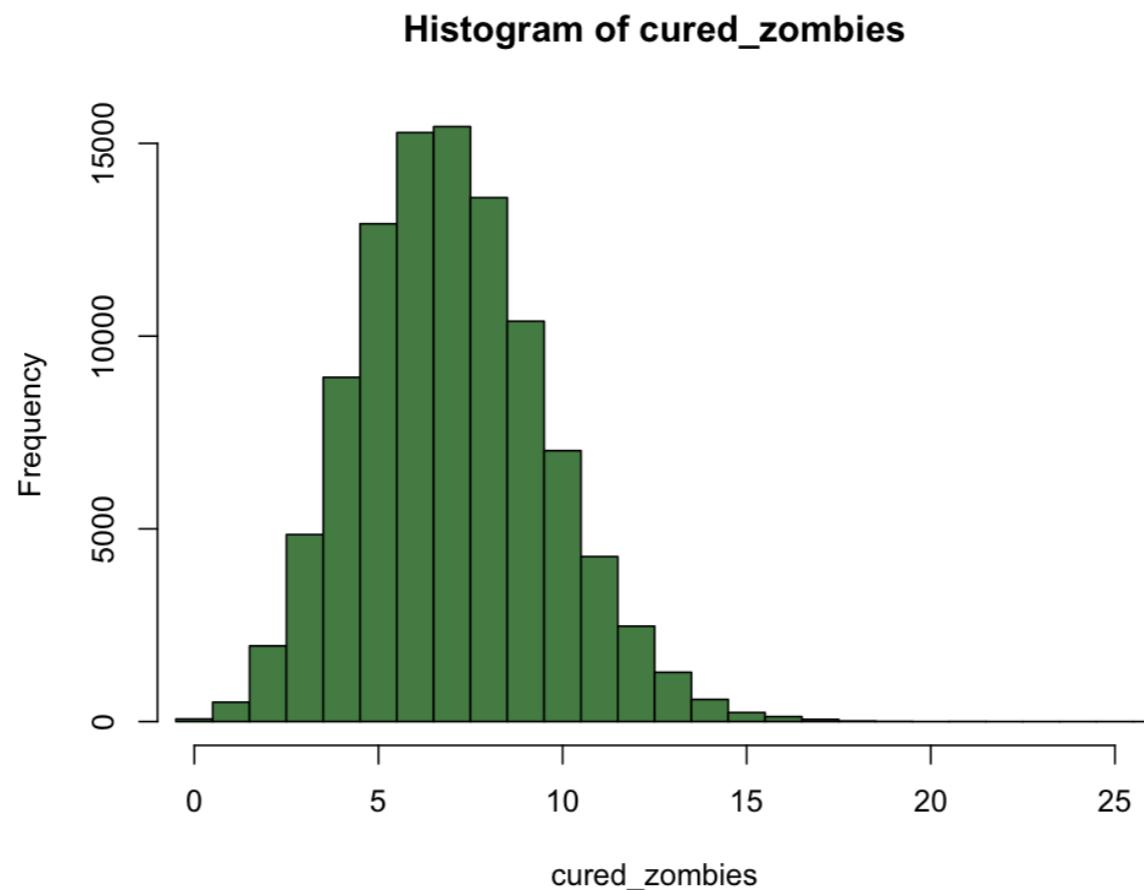
```
cured_zombies <- rbinom(n = 100000, size = 100, prob = 0.07)
```

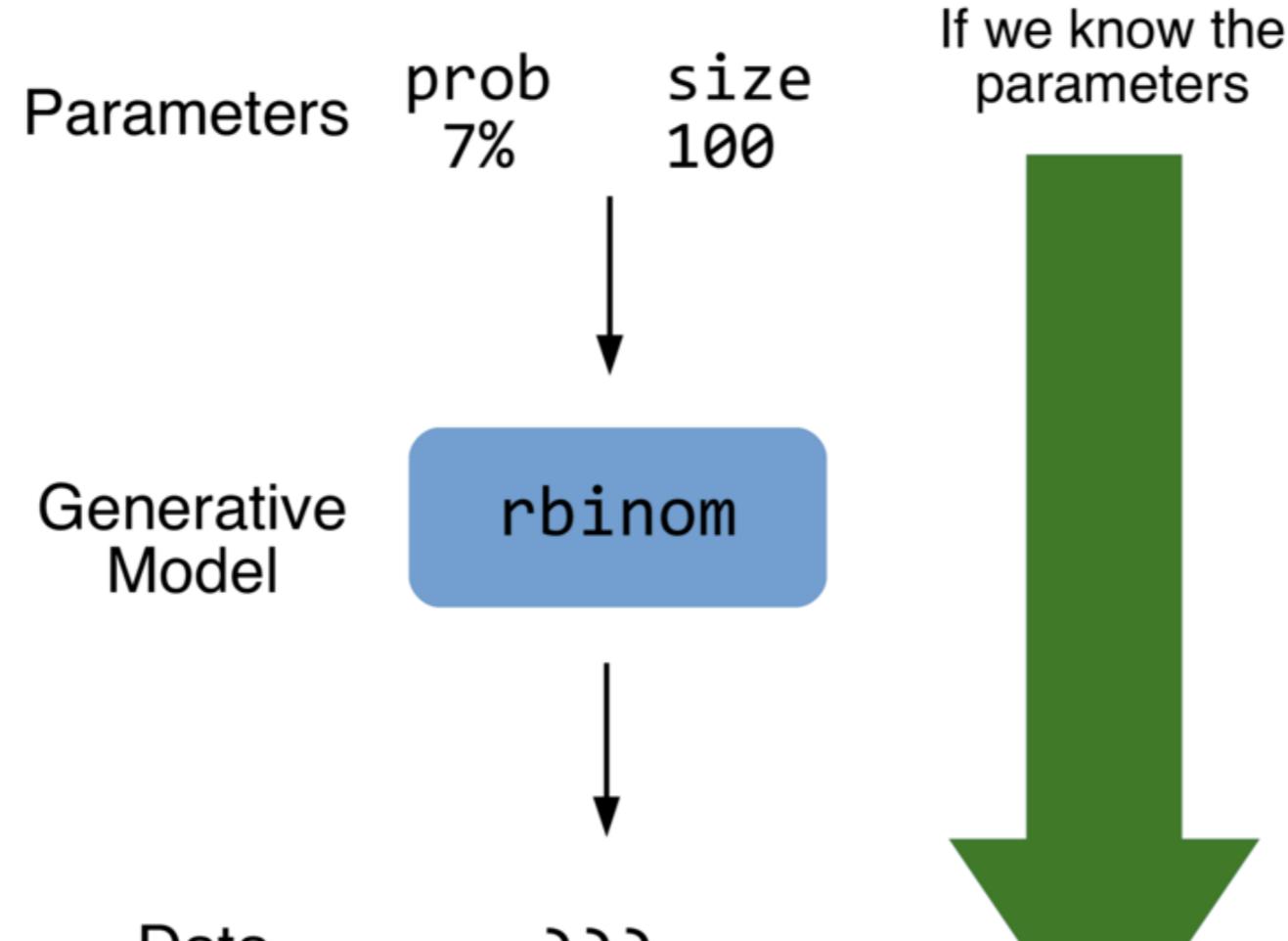
```
cured_zombies
```

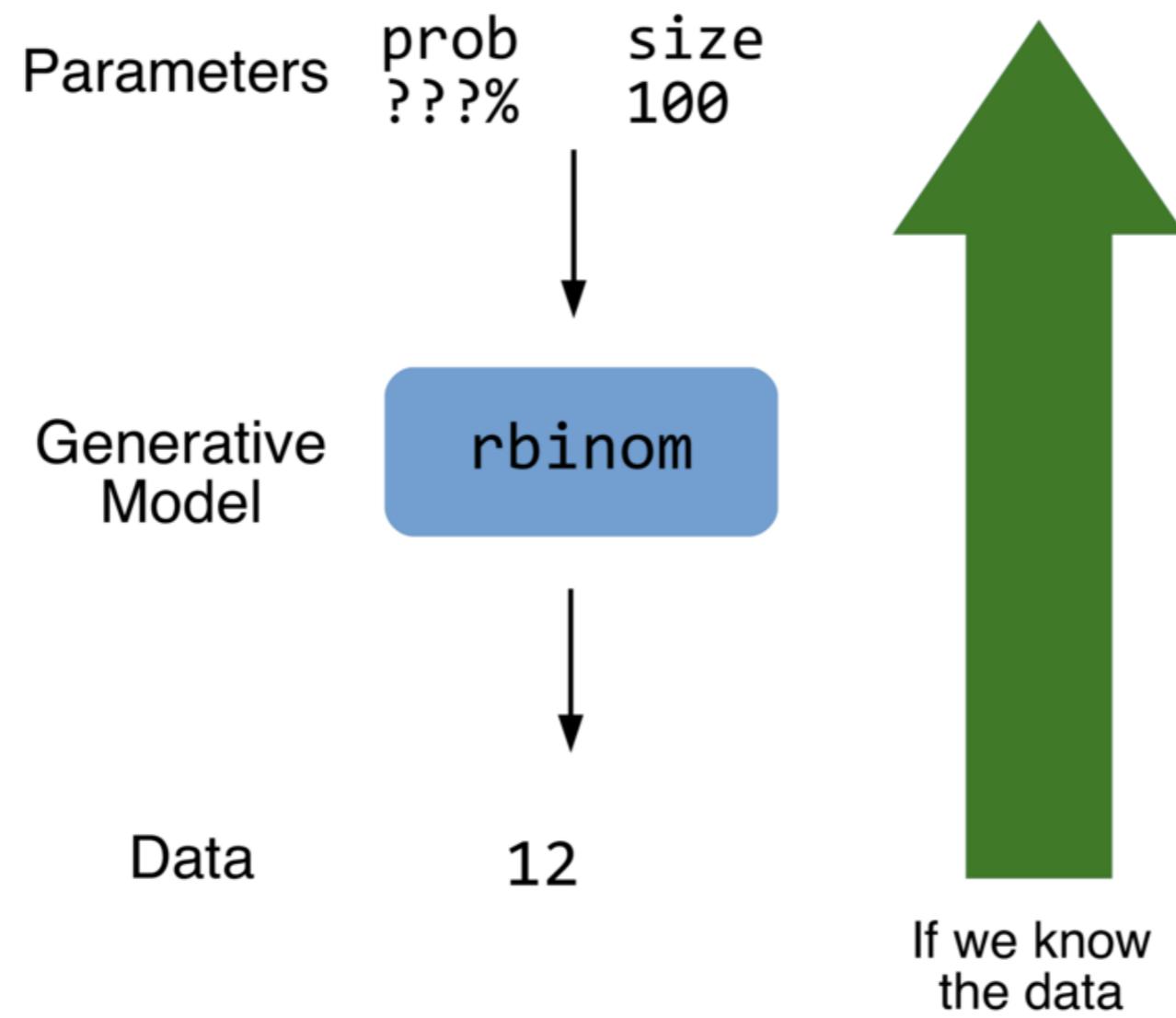
```
8   6   5   8  11  5   7   7   5   8   7  11  6   8   8  
9   9   4   7  4   8   7   5   5   6   9  14  4   4   8  
...  
...
```

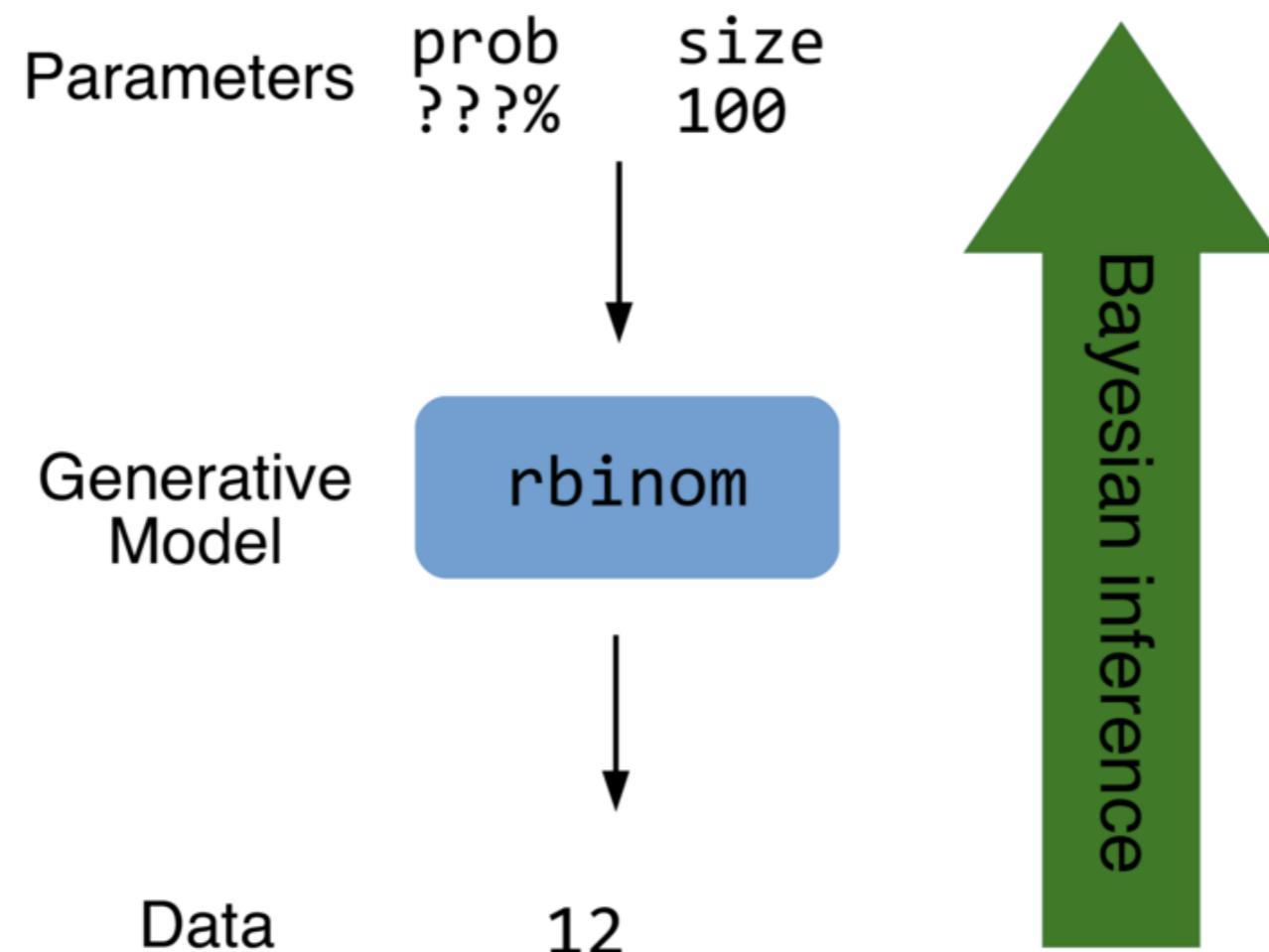
```
cured_zombies <- rbinom(n = 100000, size = 100, prob = 0.07)
```

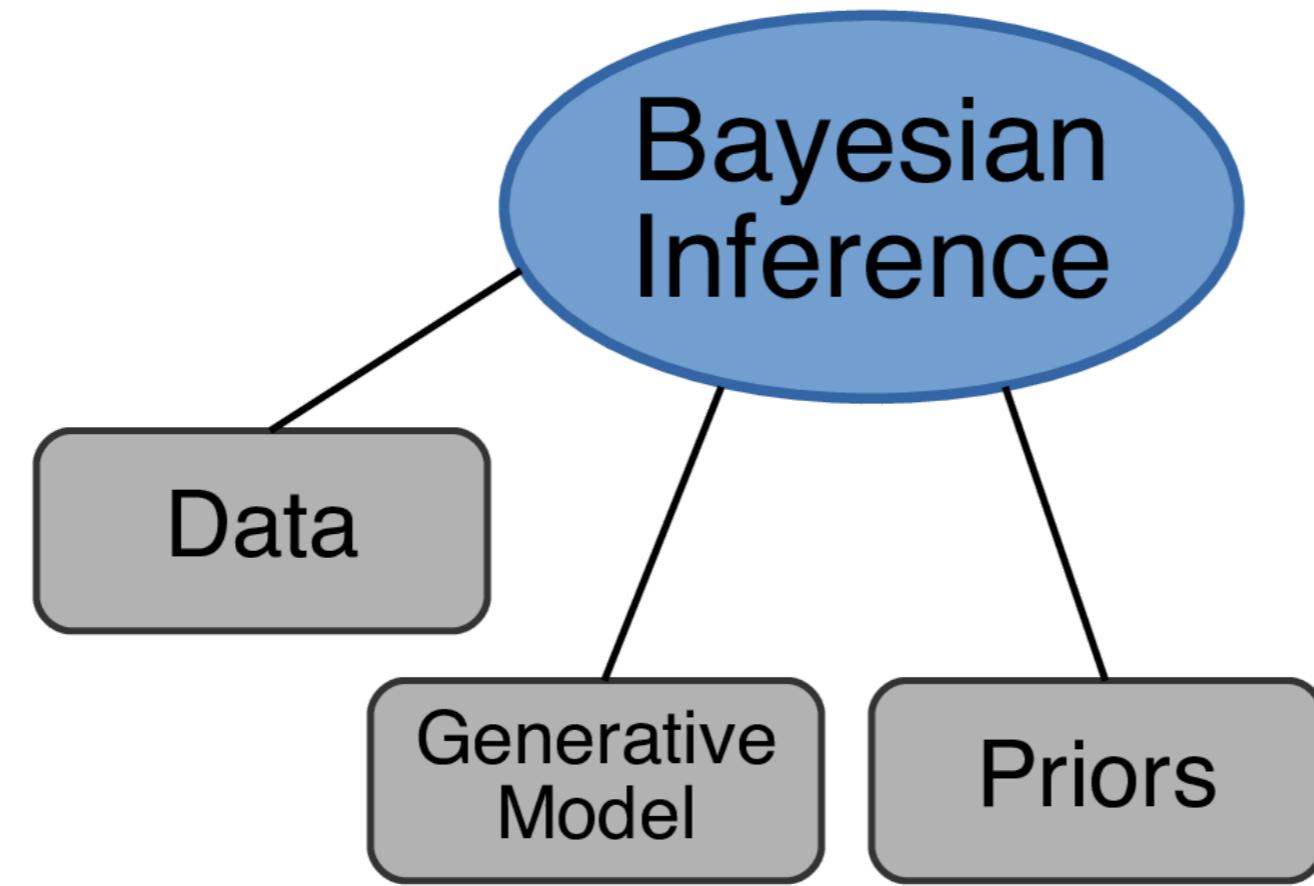
```
hist(cured_zombies)
```

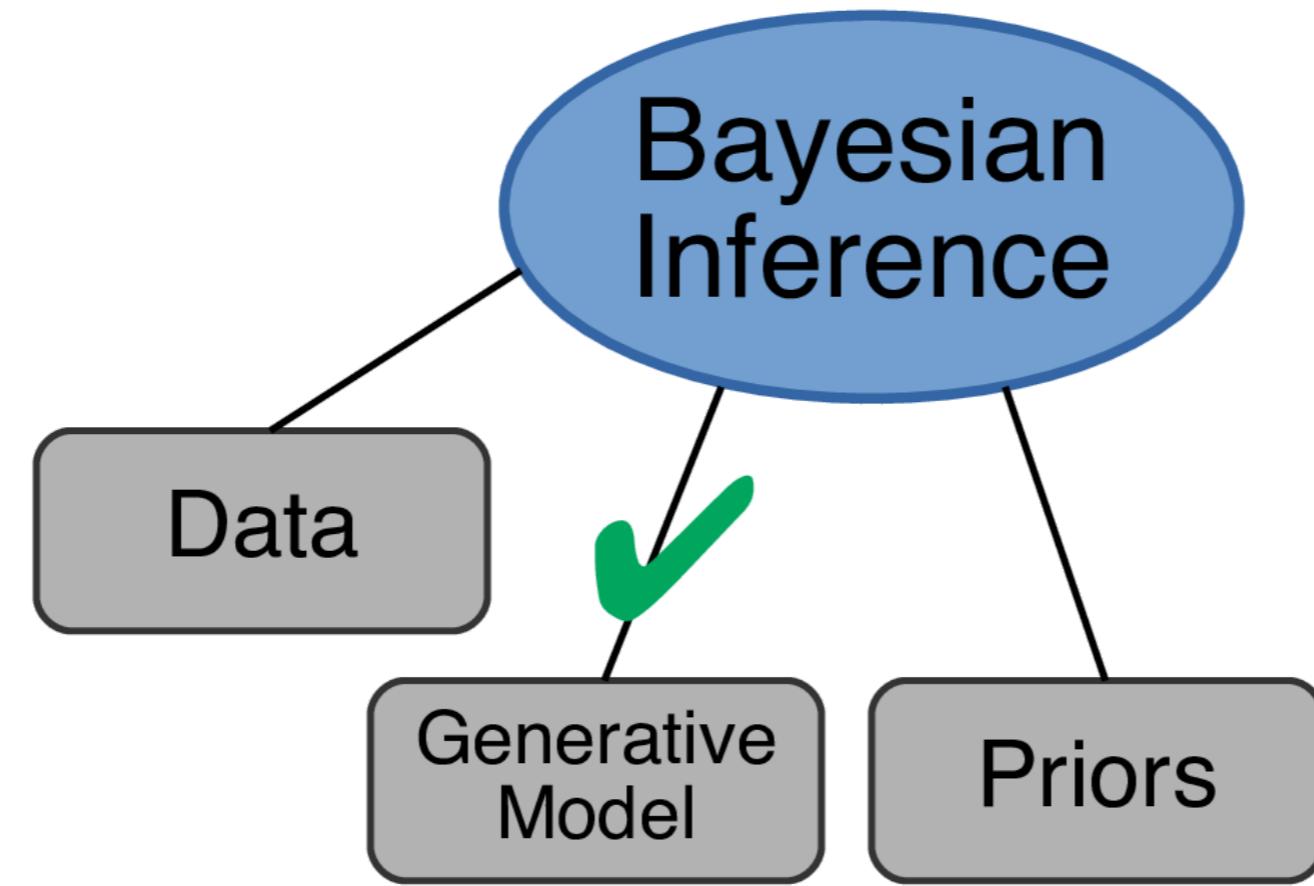














¹ https://commons.wikimedia.org/wiki/File:The_Hoard_III_-_Flickr_-_SoulStealer.co.uk.jpg





How many visitors?

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

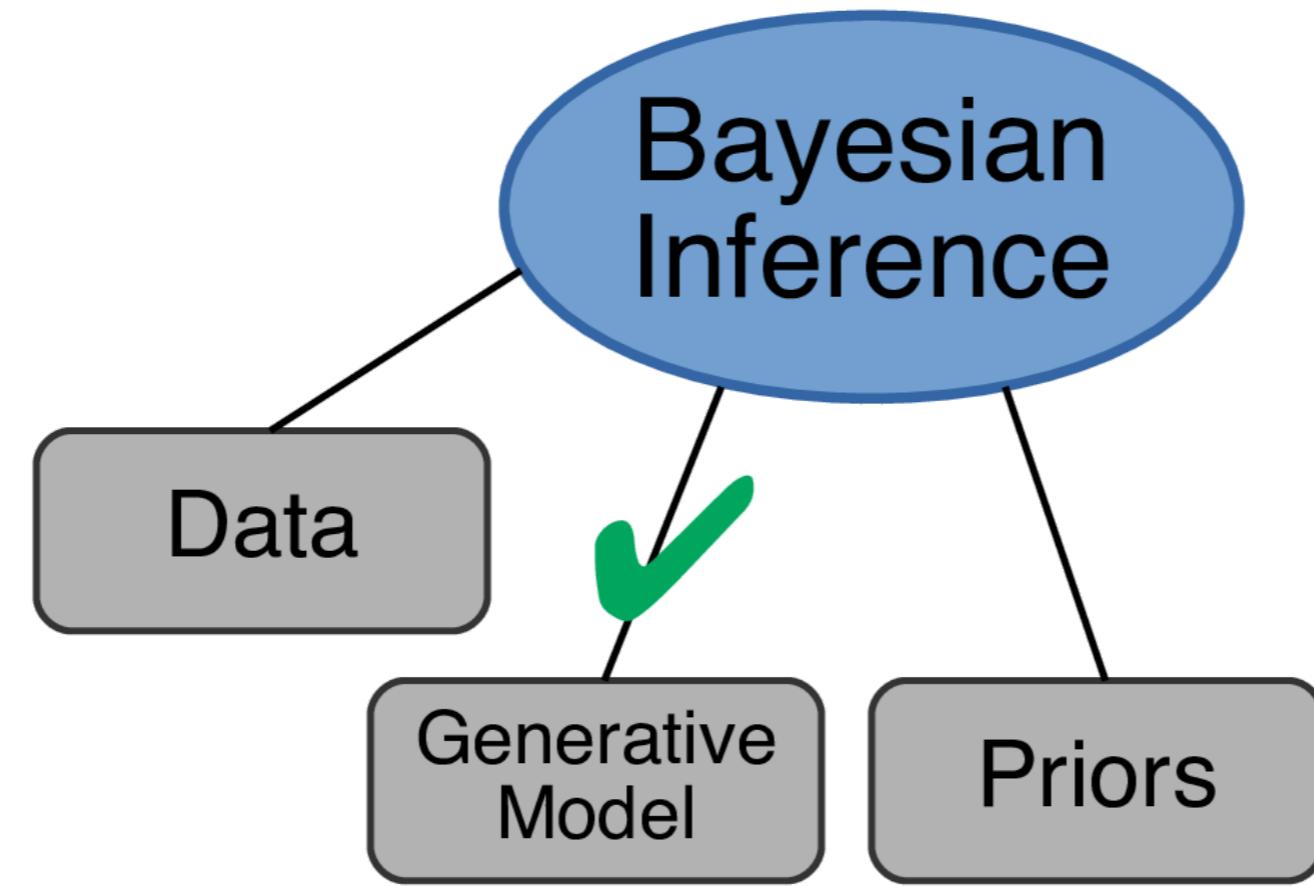
One more part

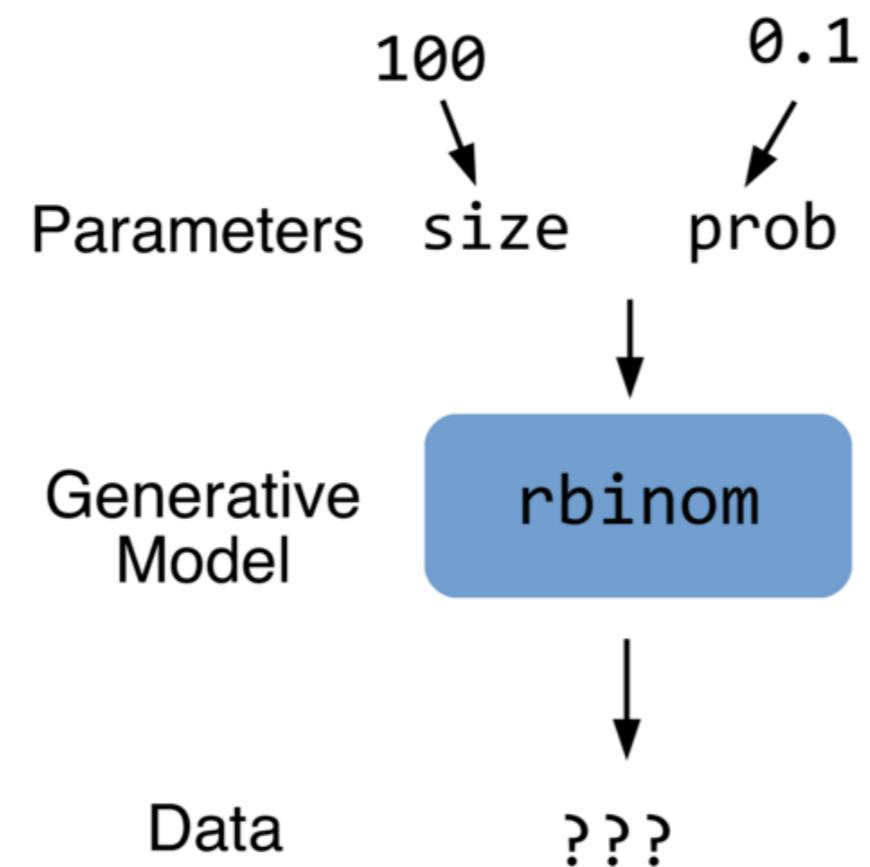
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

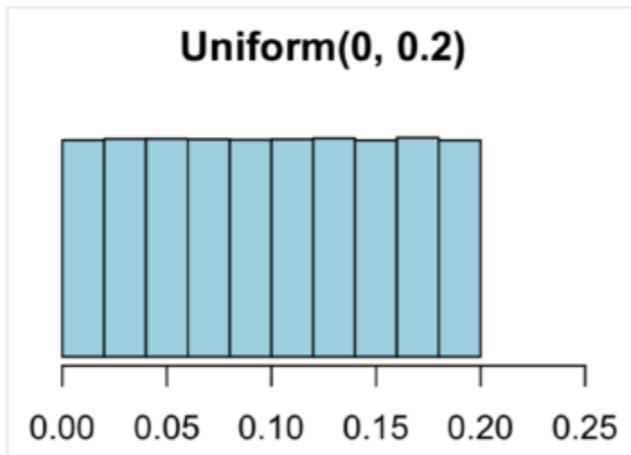


Rasmus Bååth

Data Scientist







Parameters size prob

Generative
Model

rbinom

Data

???

rbinom Bayesian model 2

```
n_samples <- 100000  
n_ads_shown <- 100  
proportion_clicks <- 0.1  
n_visitors <- rbinom(n_samples, size = n_ads_shown,  
                      prob = proportion_clicks)
```

runif - Random Uniform samples

runif - Random Uniform samples

```
proportion_clicks <- runif(n = 6, min = 0.0, max = 1.0)
```

```
proportion_clicks
```

```
0.05  0.58  0.21  0.61  0.69  0.39
```

runif - Random Uniform samples

```
proportion_clicks <- runif(n = 6, min = 0.0, max = 1.0)  
n_clicks <- rbinom(n = 6, size = 100, proportion_clicks)
```

```
proportion_clicks
```

```
0.05 0.58 0.21 0.61 0.69 0.39
```

runif - Random Uniform samples

```
proportion_clicks <- runif(n = 6, min = 0.0, max = 1.0)  
n_clicks <- rbinom(n = 6, size = 100, proportion_clicks)
```

proportion_clicks

```
0.05  0.58  0.21  0.61  0.69  0.39
```

n_clicks

```
7      59     13     63     67     29
```

Try this in practice!

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

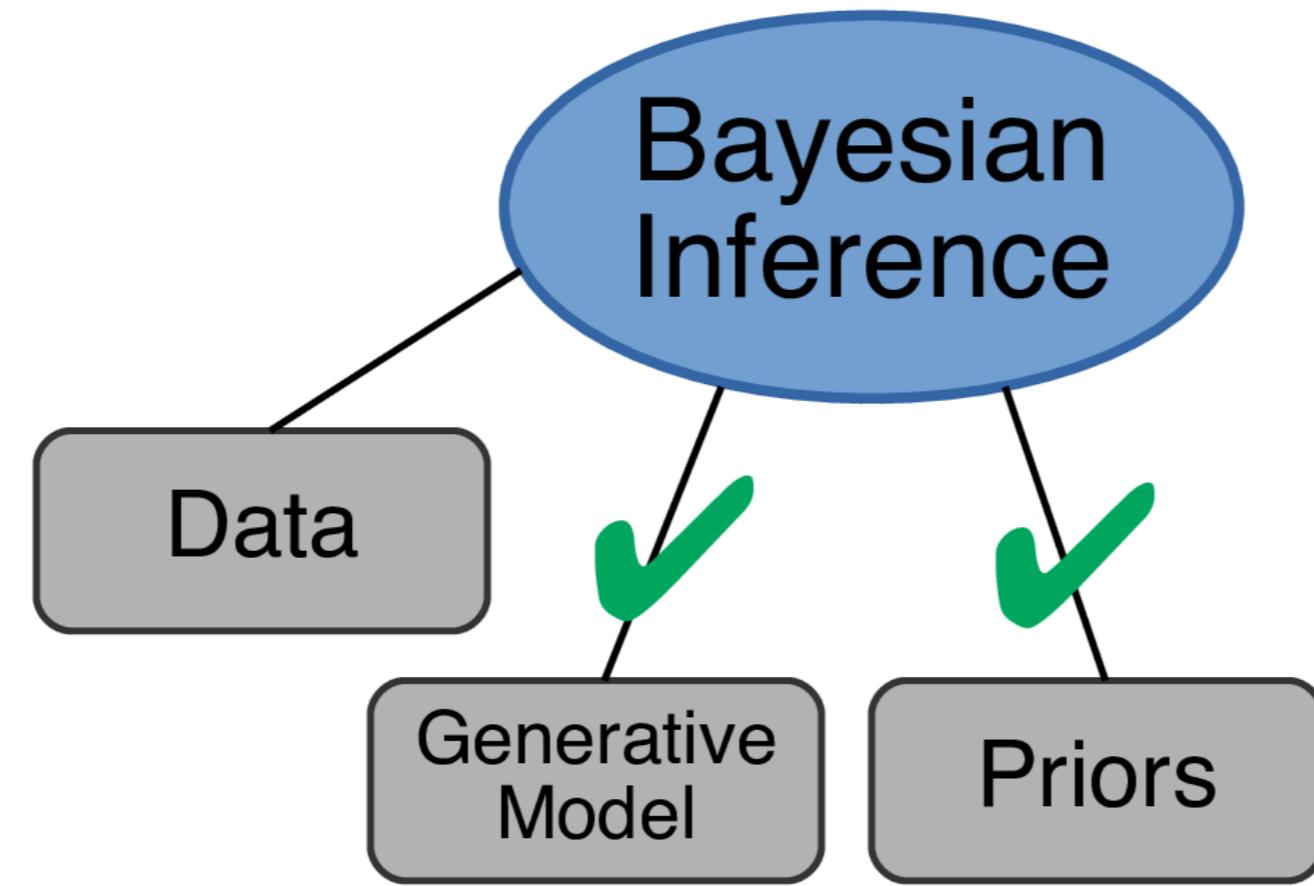
Bayesian models and conditioning

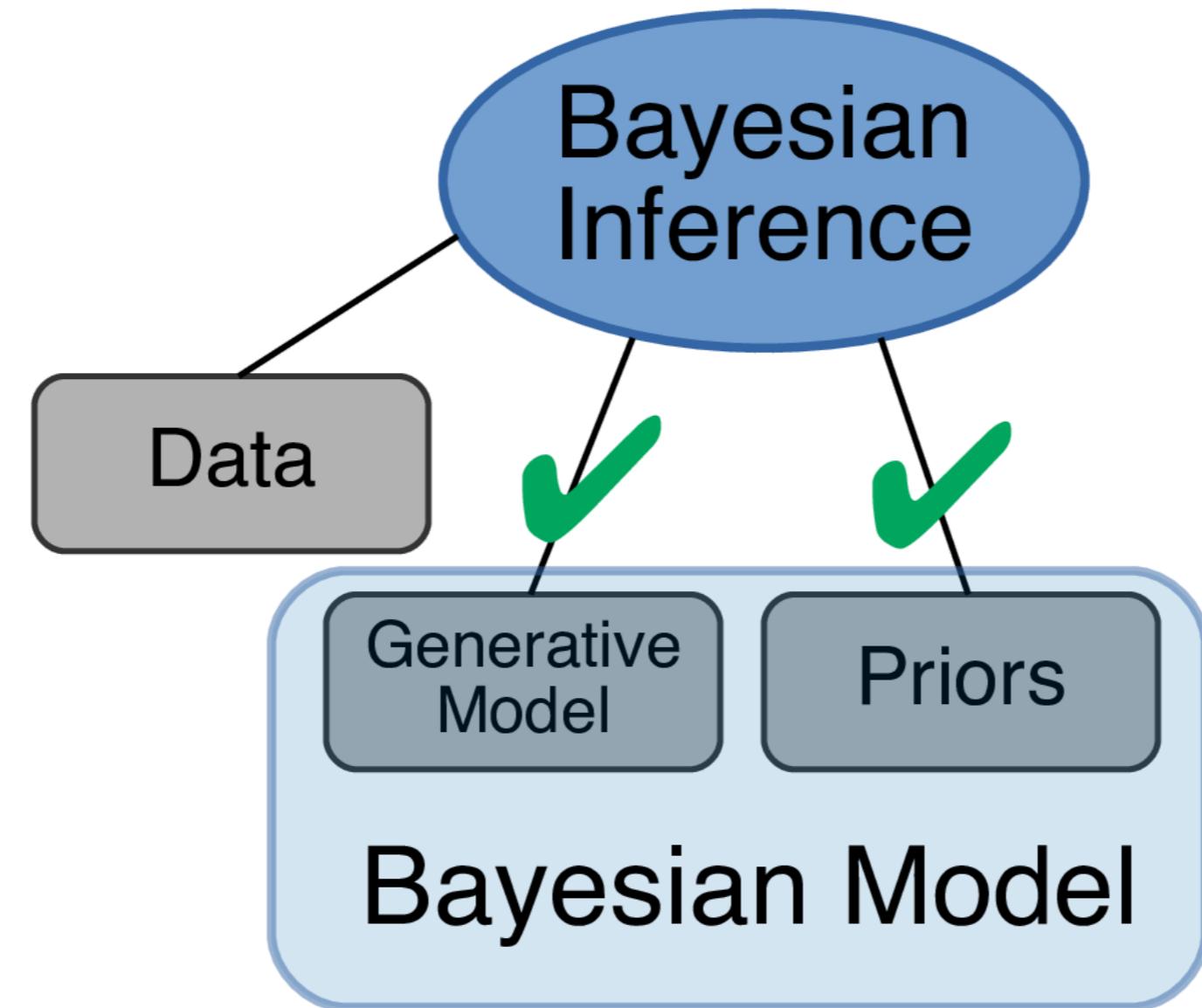
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R



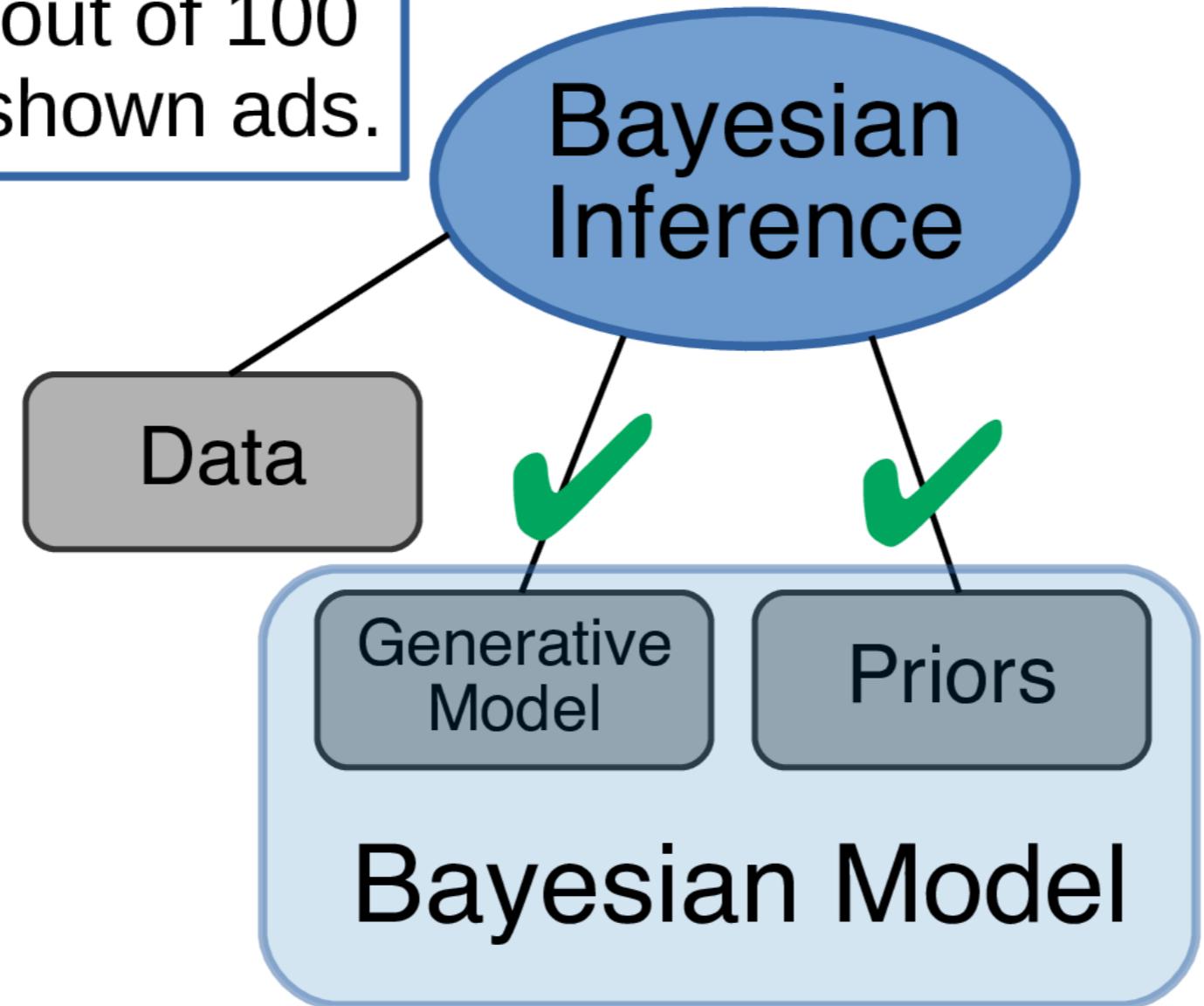
Rasmus Bååth

Data Scientist

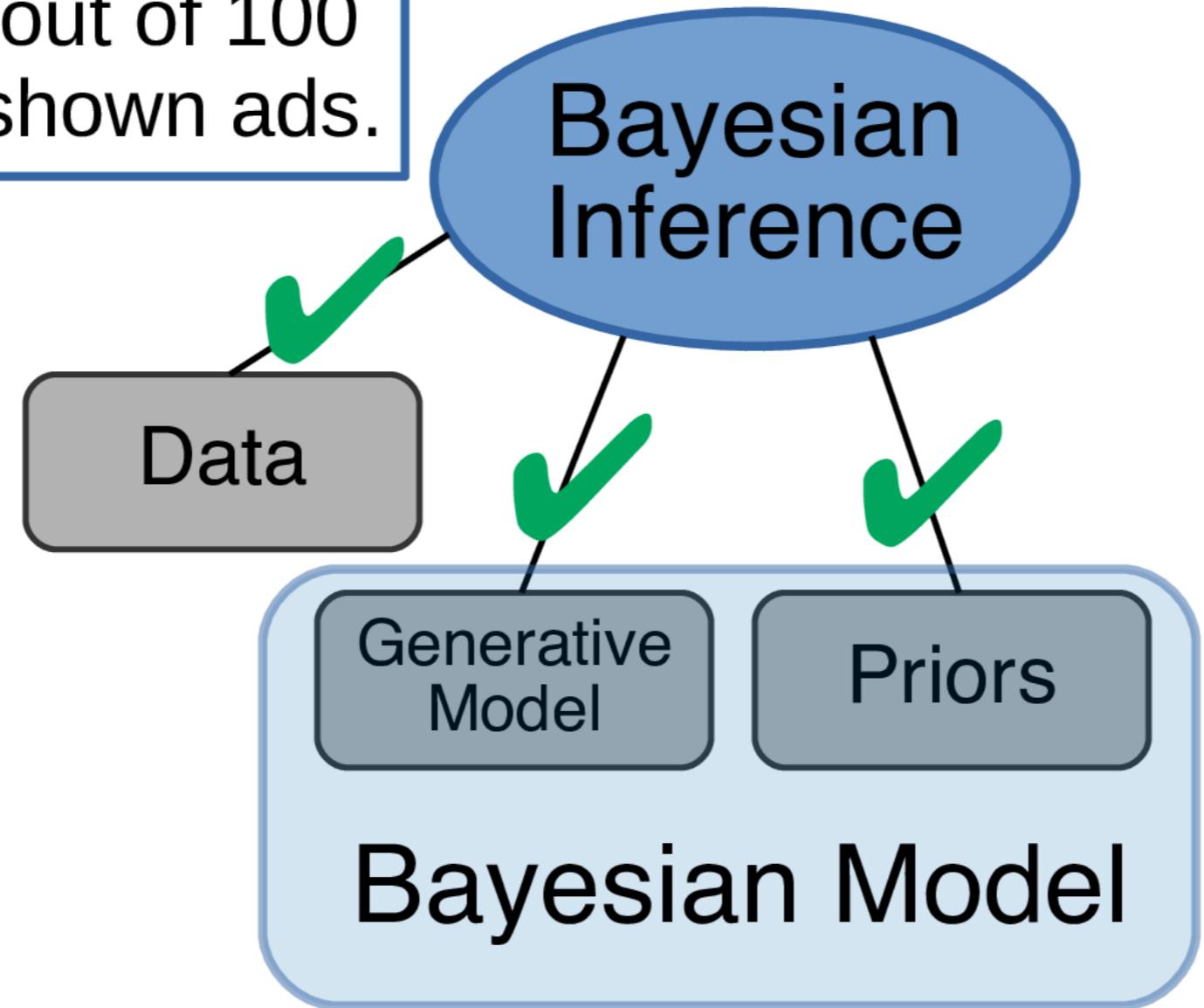




13 clicked
out of 100
shown ads.



13 clicked
out of 100
shown ads.

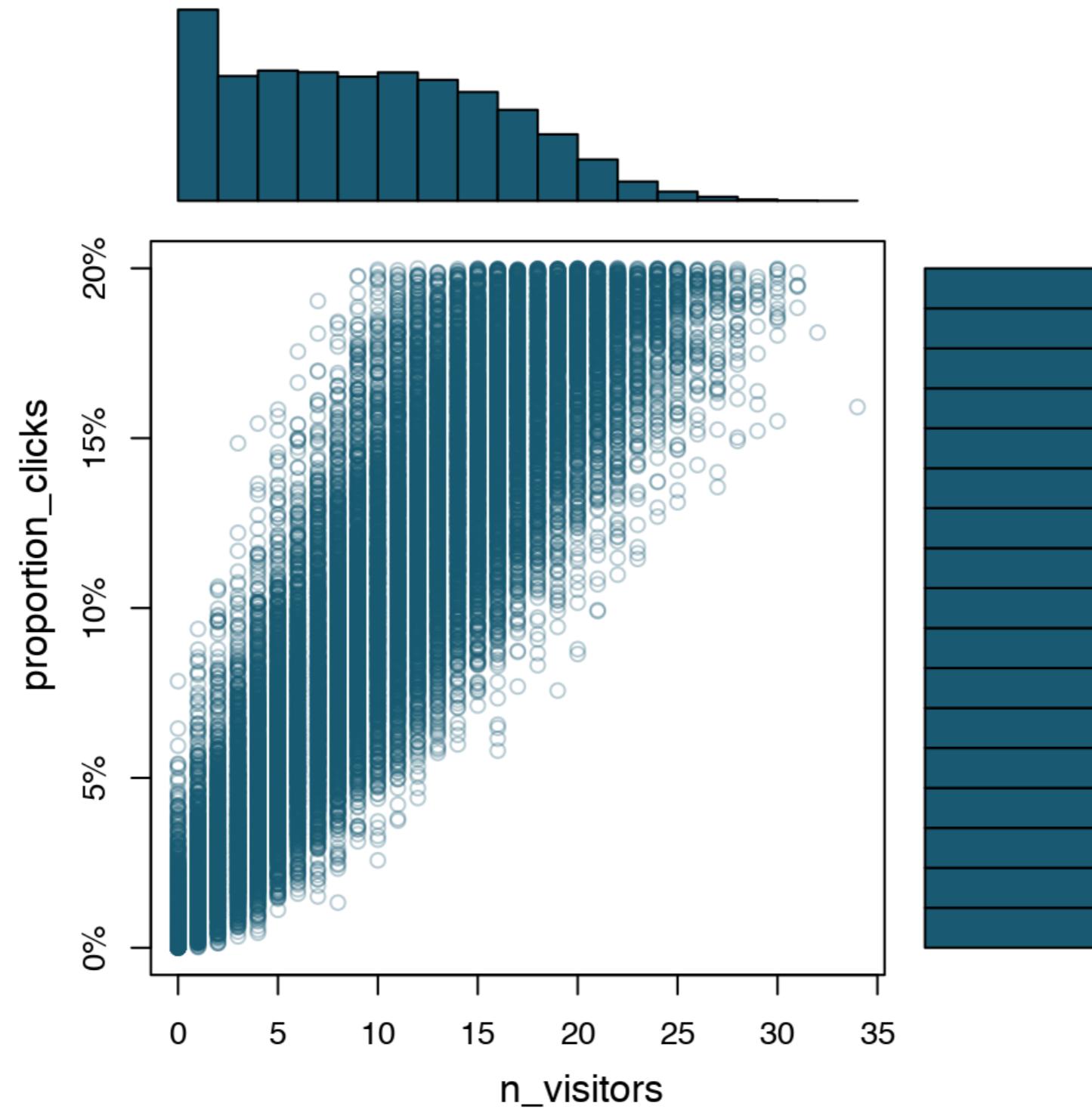


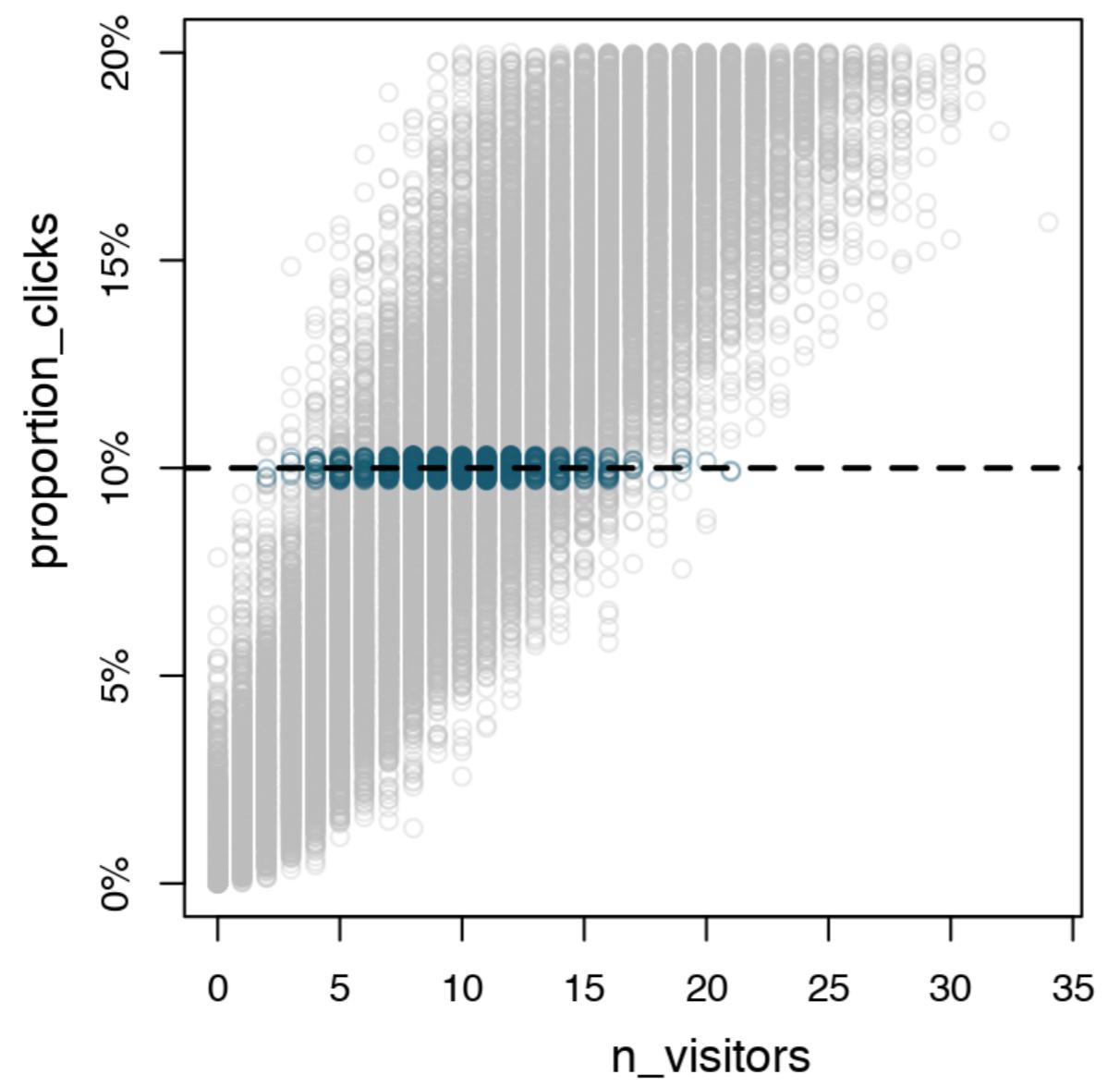
```
n_samples <- 100000  
n_ads_shown <- 100  
proportion_clicks <- runif(n_samples, min = 0.0, max = 0.2)  
n_visitors <- rbinom(n = n_samples, size = n_ads_shown,  
                      prob = proportion_clicks)
```

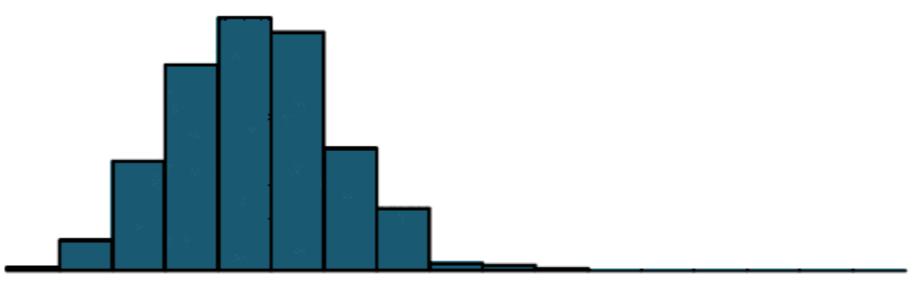
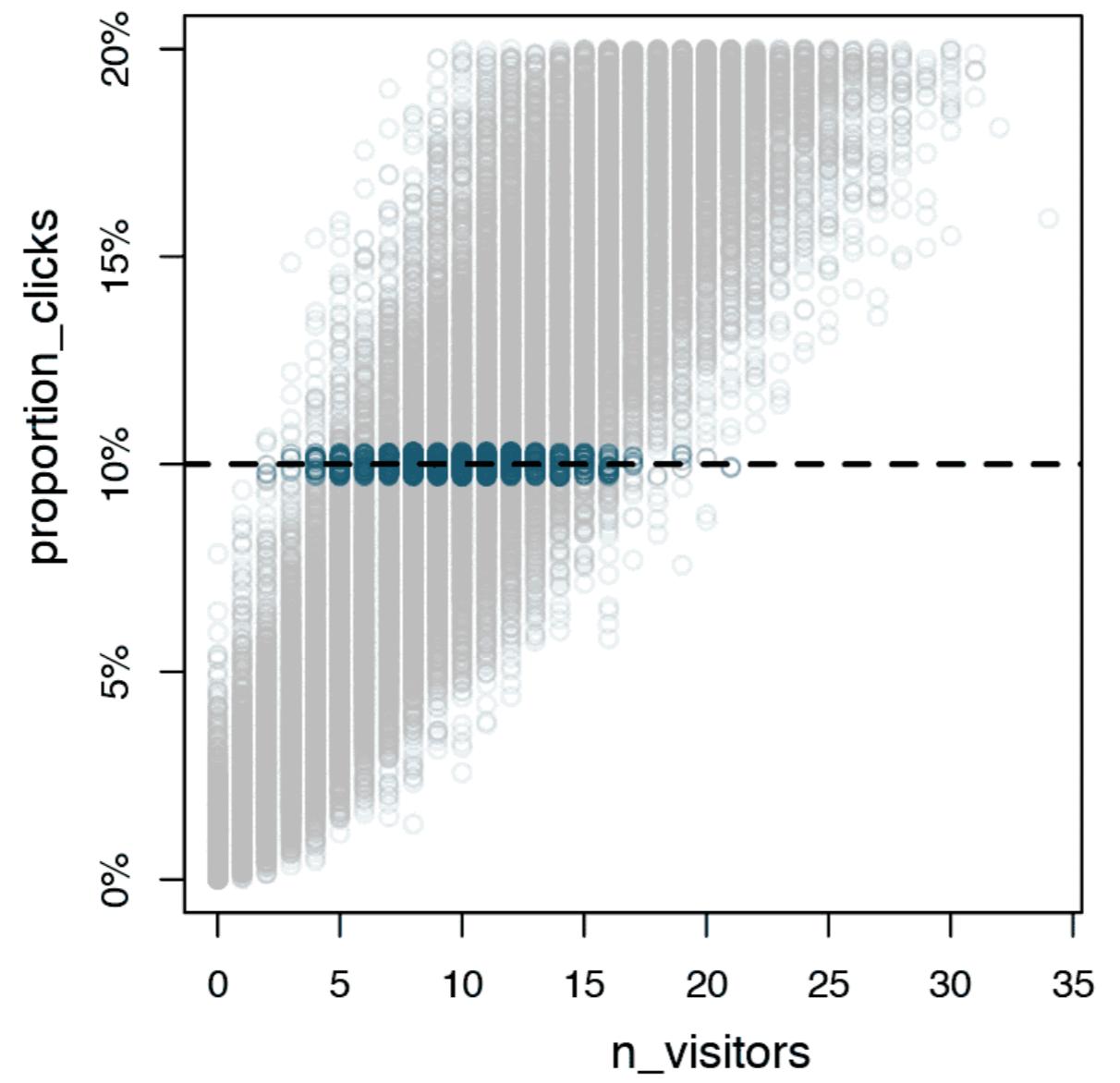
```
n_samples <- 100000  
n_ads_shown <- 100  
proportion_clicks <- runif(n_samples, min = 0.0, max = 0.2)  
n_visitors <- rbinom(n = n_samples, size = n_ads_shown,  
                      prob = proportion_clicks)  
prior <- data.frame(proportion_clicks, n_visitors)
```

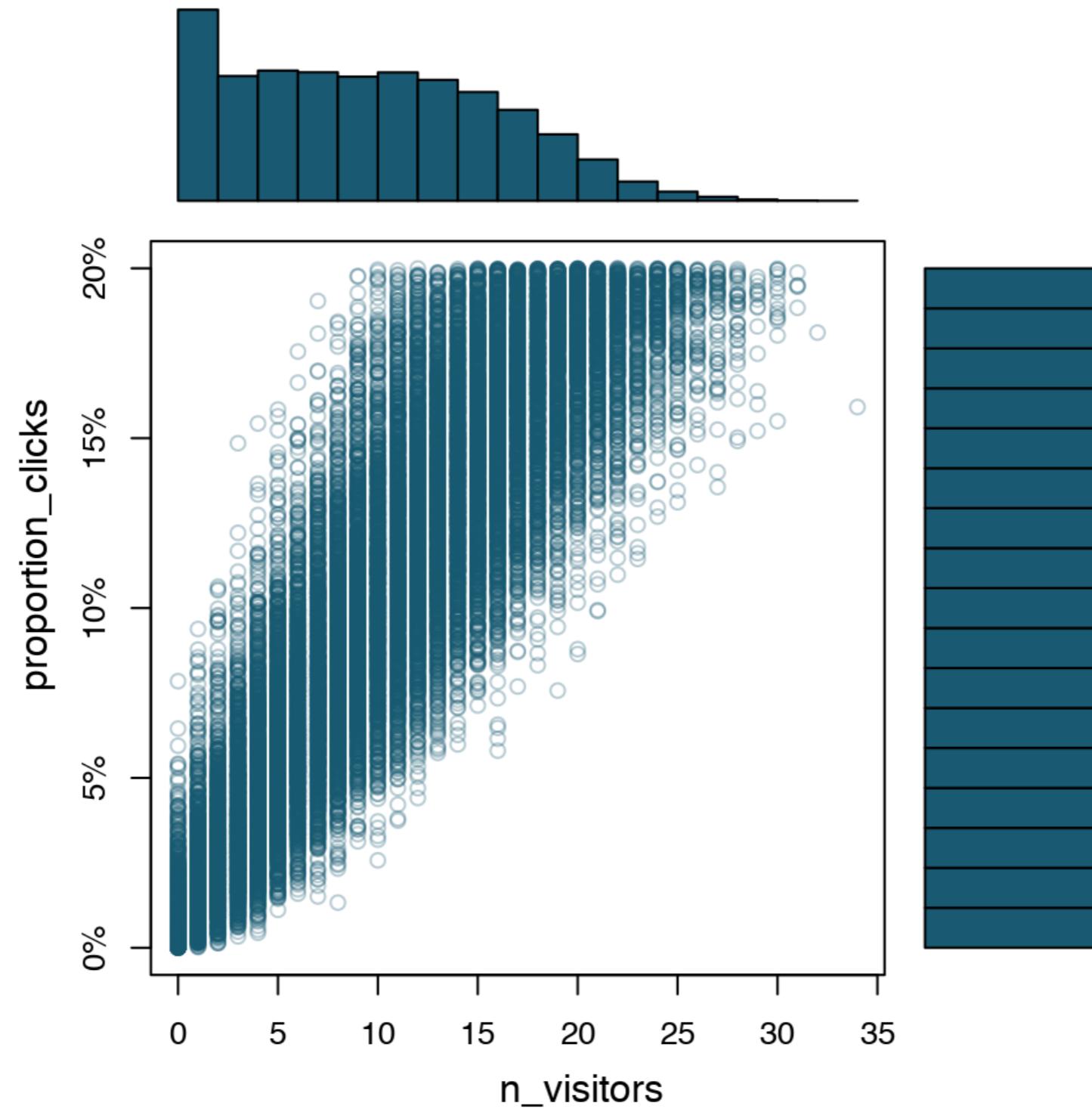
prior

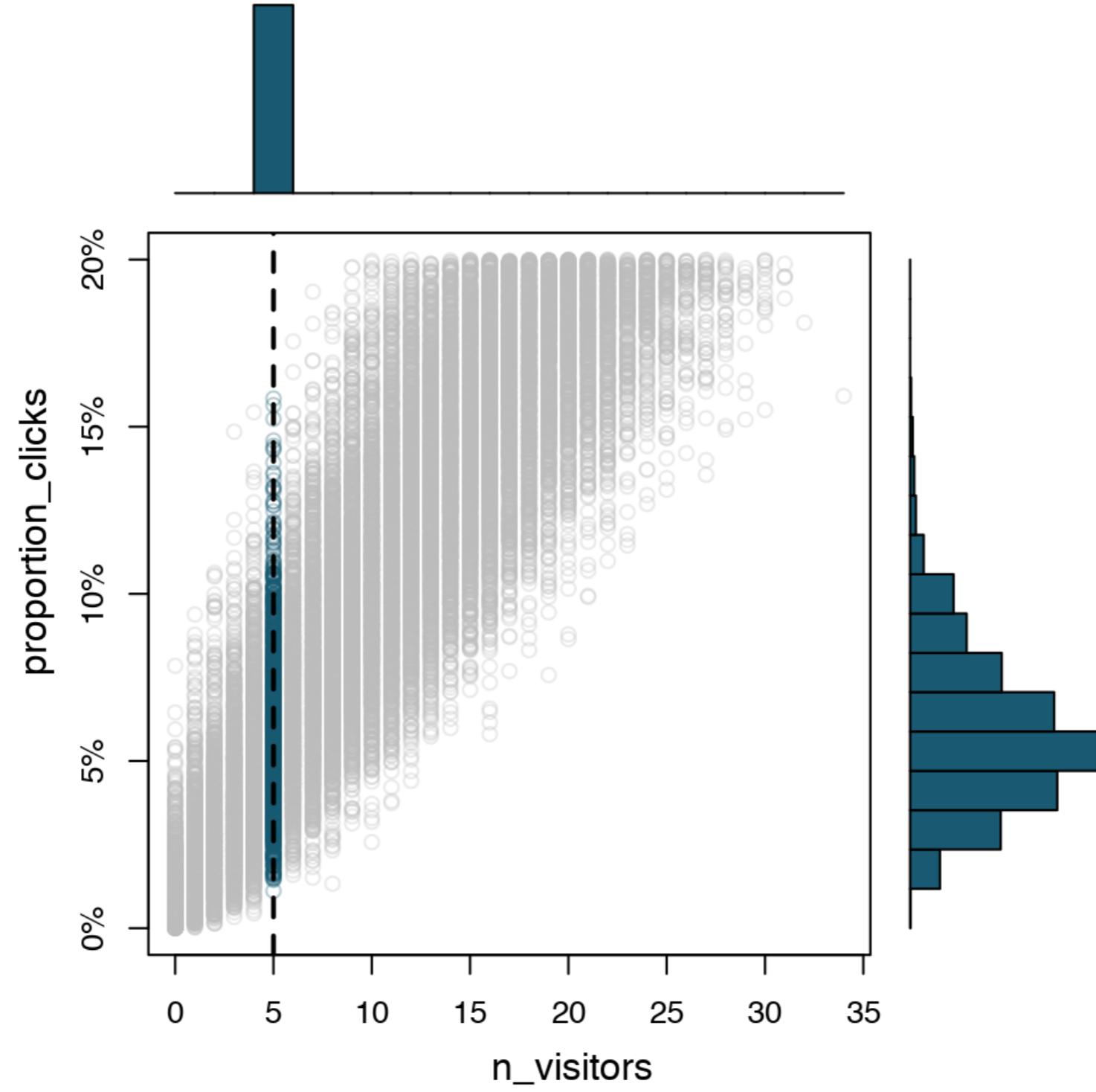
	proportion_clicks	n_visitors
1	0.12	10
2	0.04	3
3	0.11	14
4	0.15	14
5	0.15	12
6	0.16	13
7	0.04	6
8	0.04	3
9	0.09	10
10	0.04	3
11	0.08	8
12	0.13	12
13	0.02	3
14	0.18	19
15	0.04	5
16	0.10	10
...

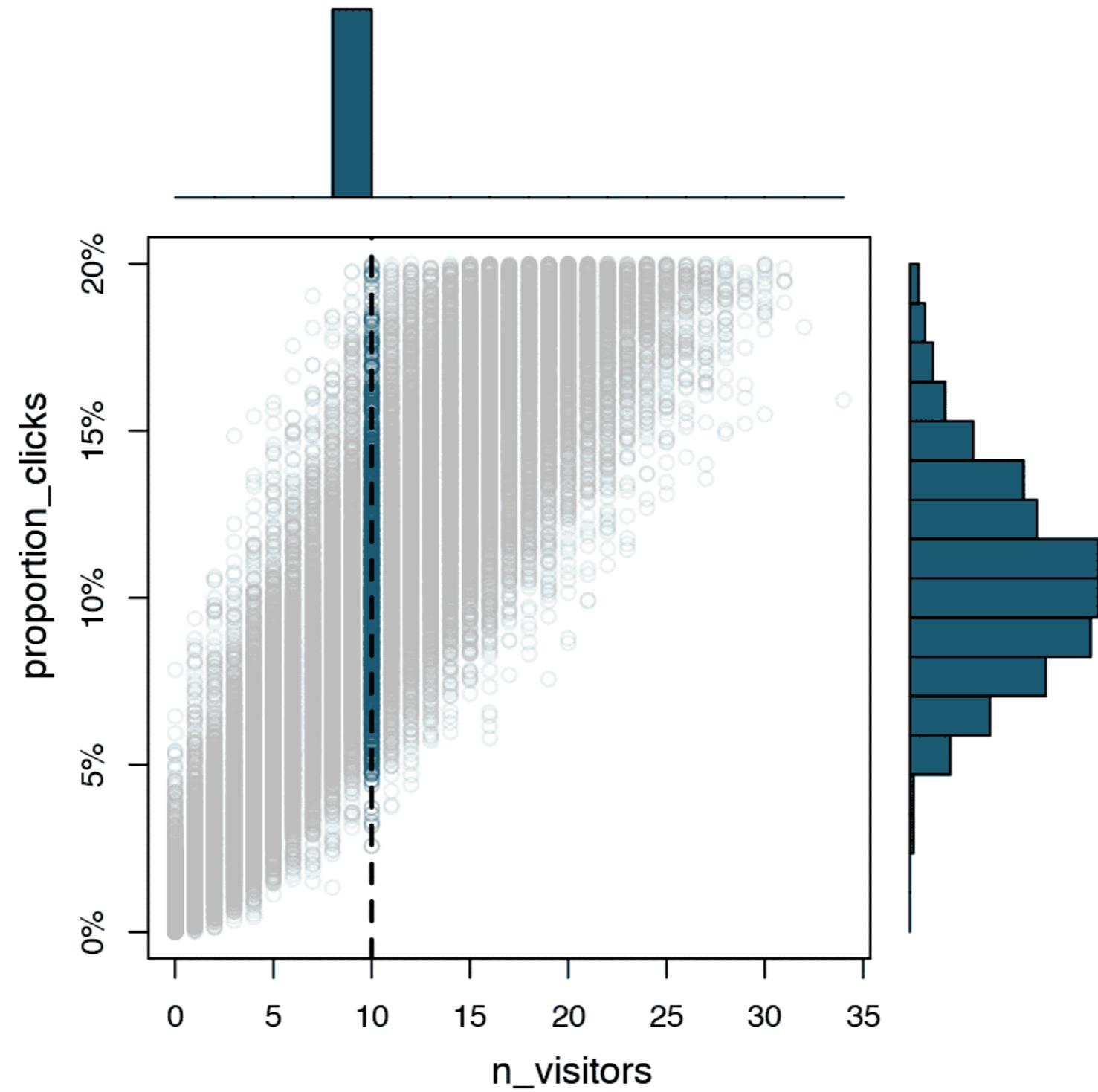












The essence of Bayesian inference

Bayesian inference is conditioning on data, in order to learn about parameter values.

Try some Bayesian inference yourself!

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

Bayesian inference, again!

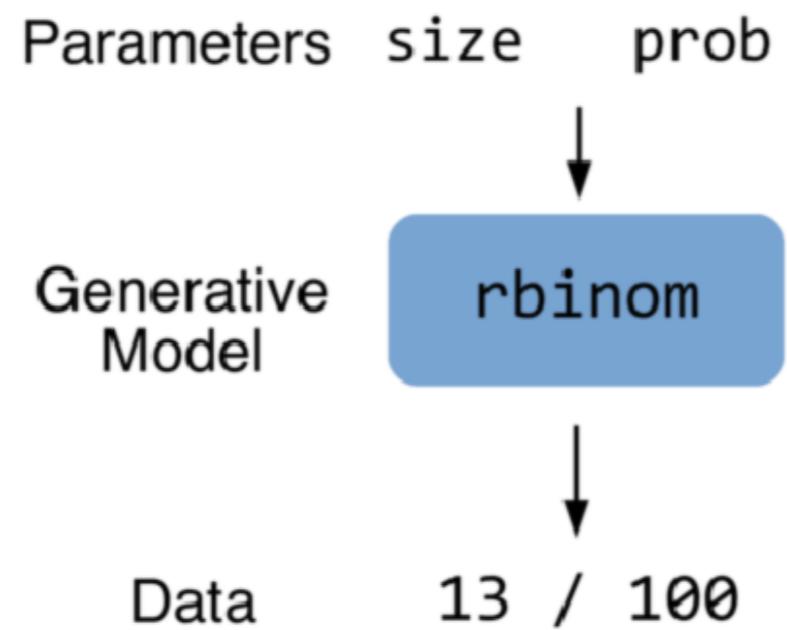
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

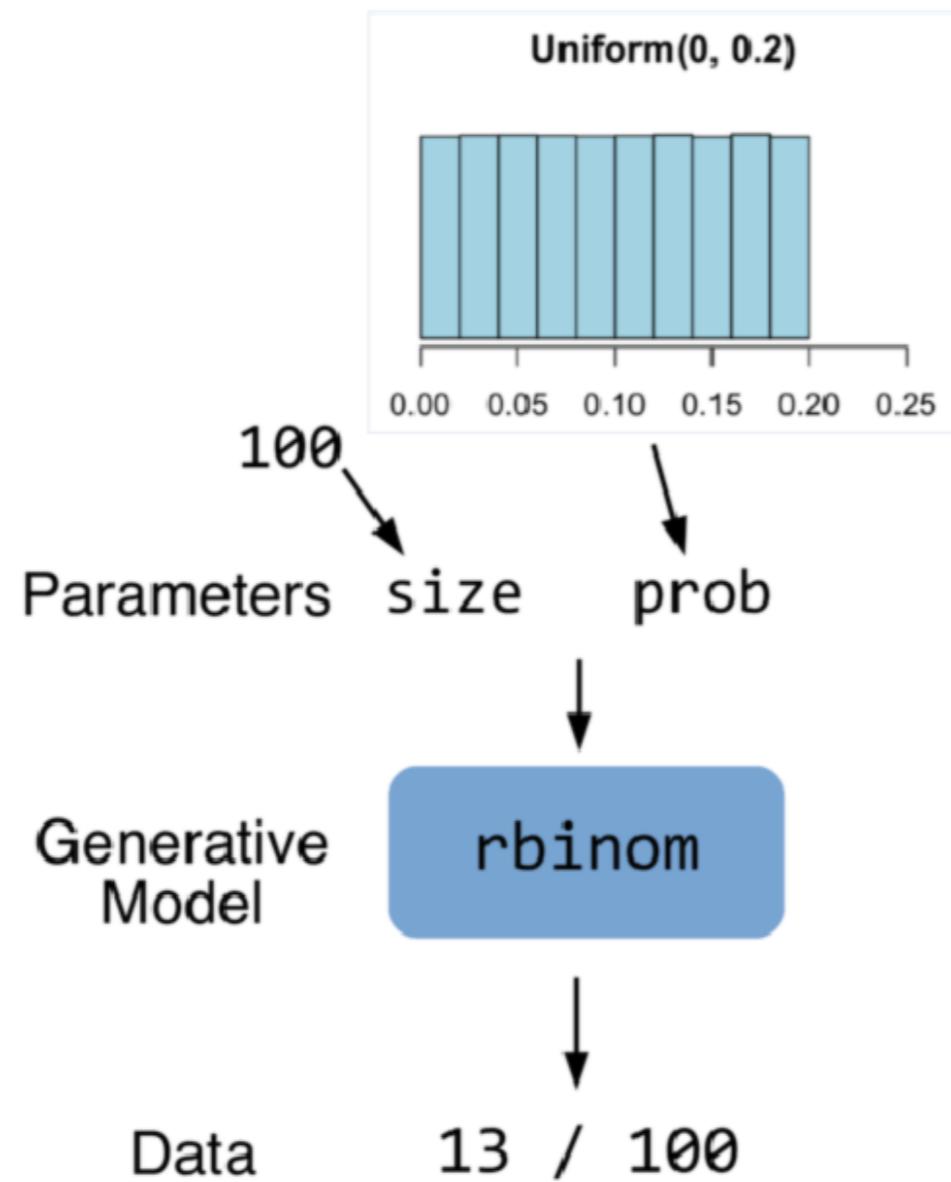


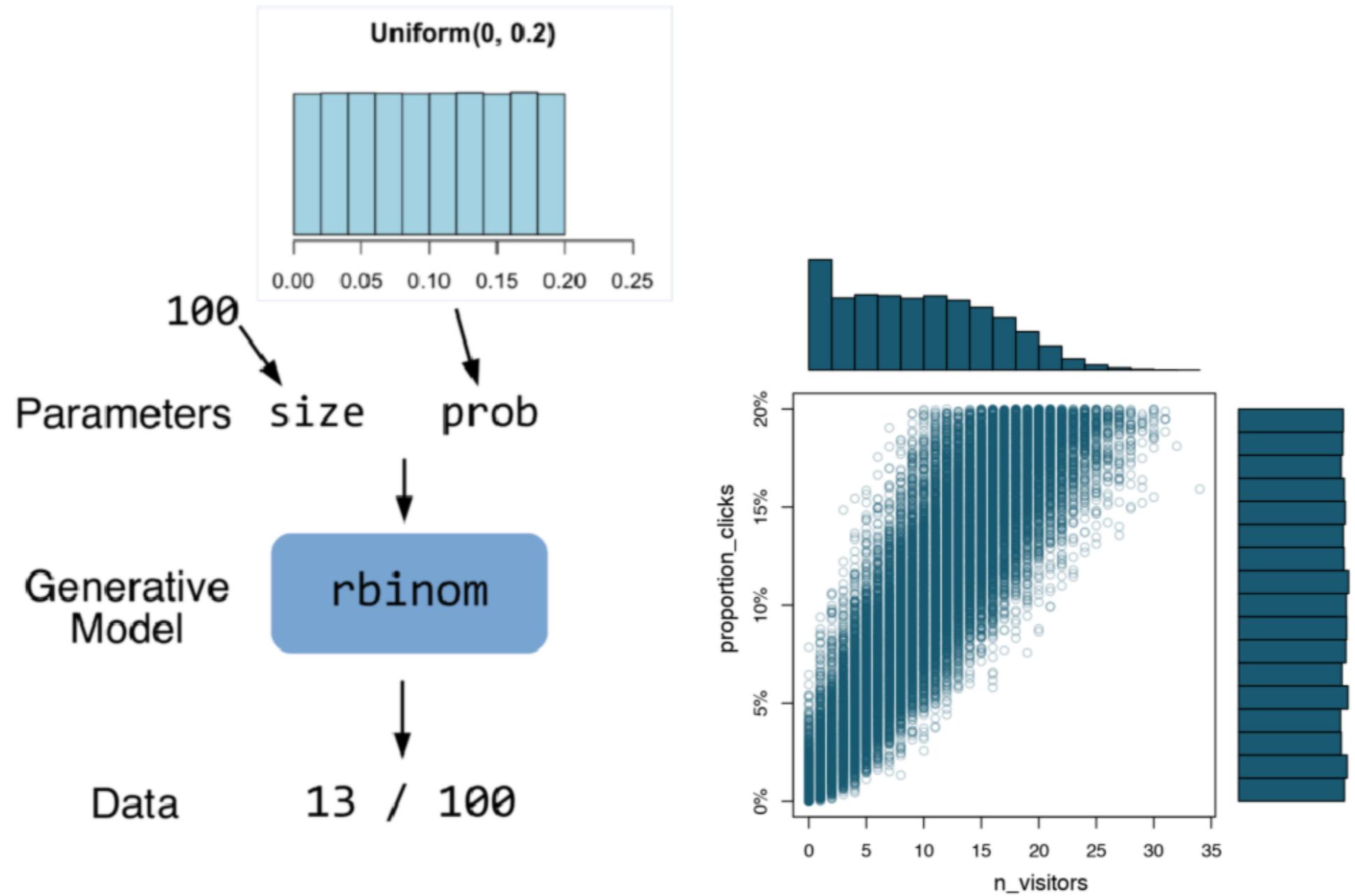
Rasmus Bååth

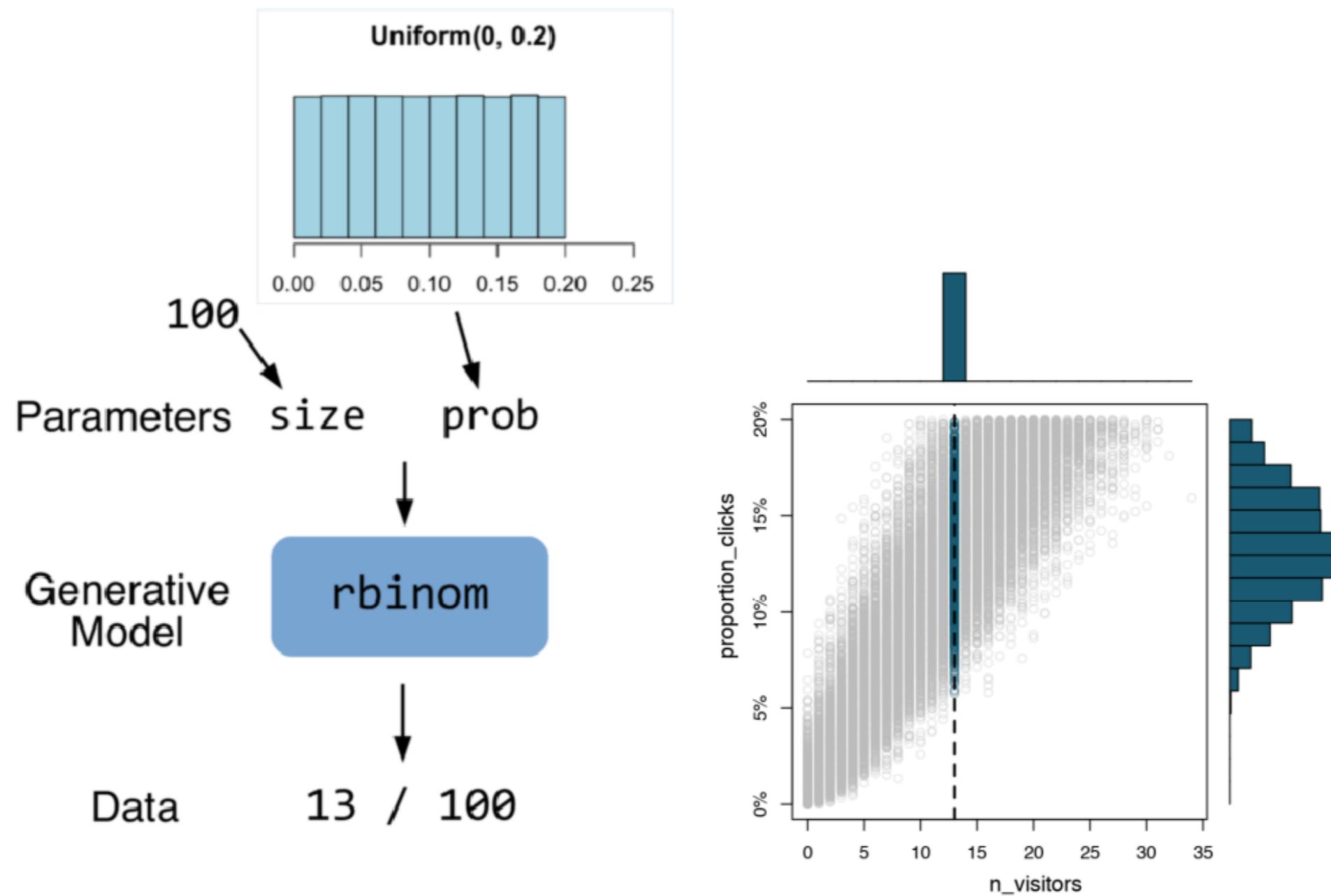
Data Scientist

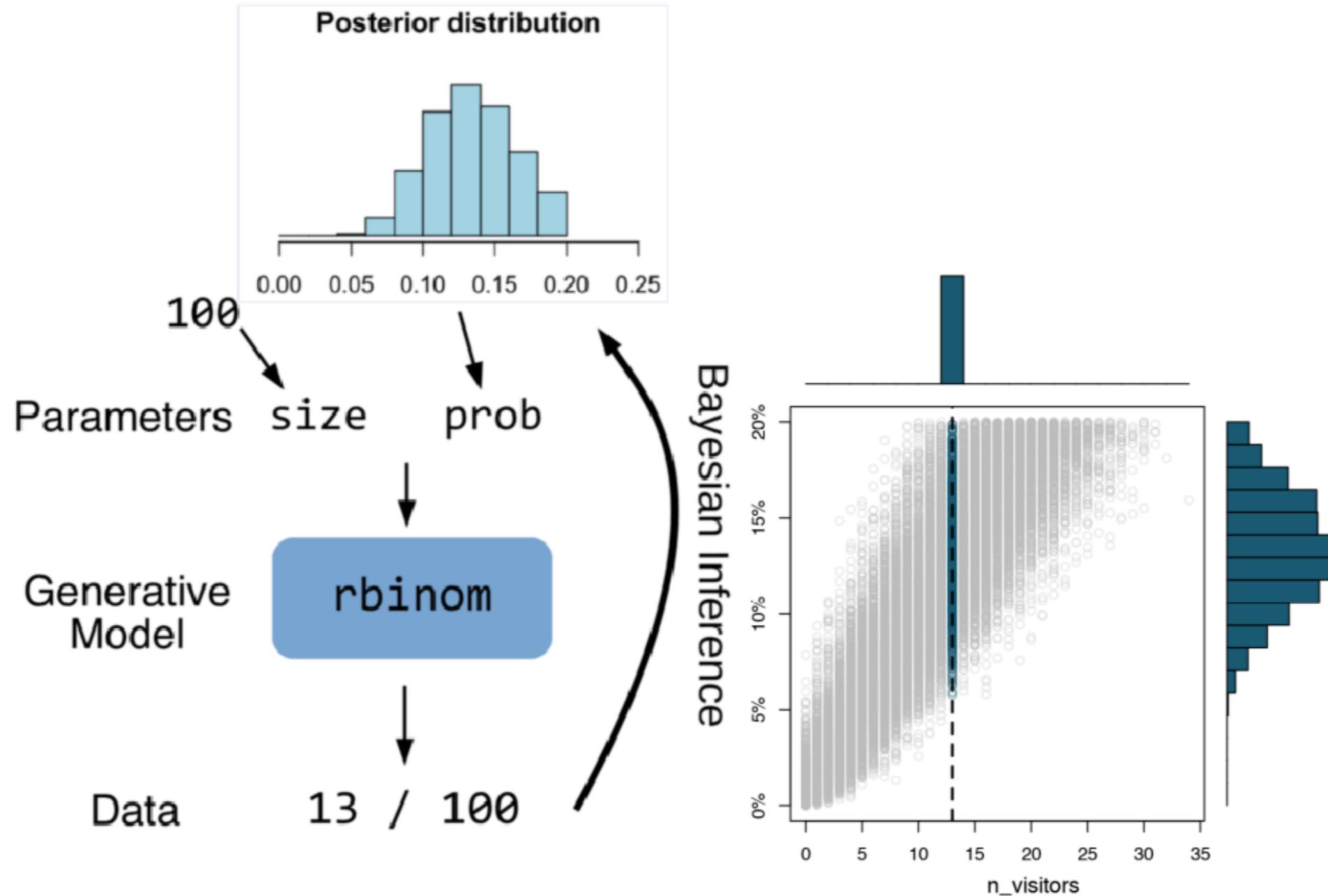
```
prop_success <- 0.1
size <- 100
# Simulating data
data <- c()
for(i in 1:size) {
  data[i] <-
    runif(1, min = 0, max = 1) <
      prop_success
}
data <- as.numeric(data)
```

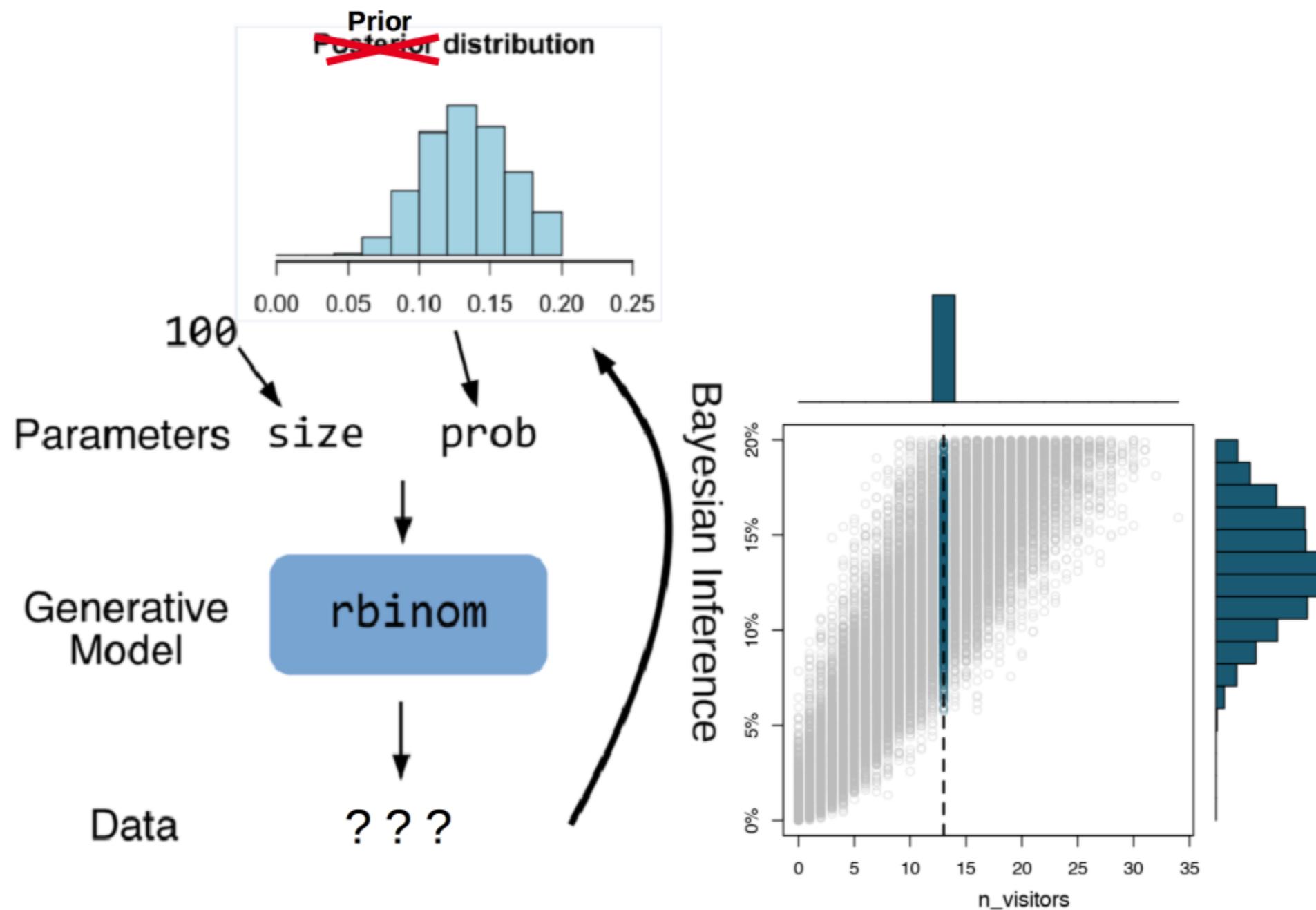


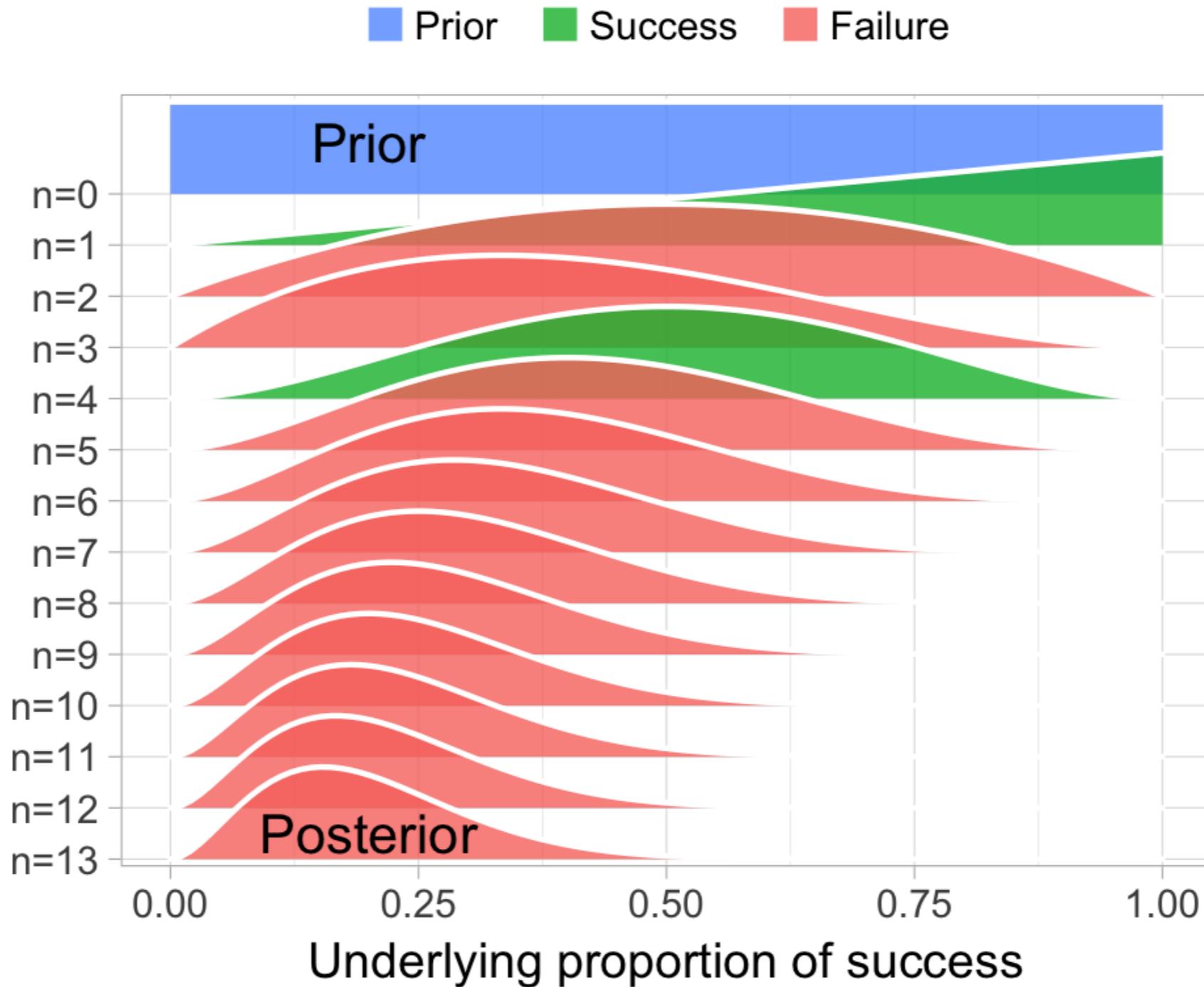


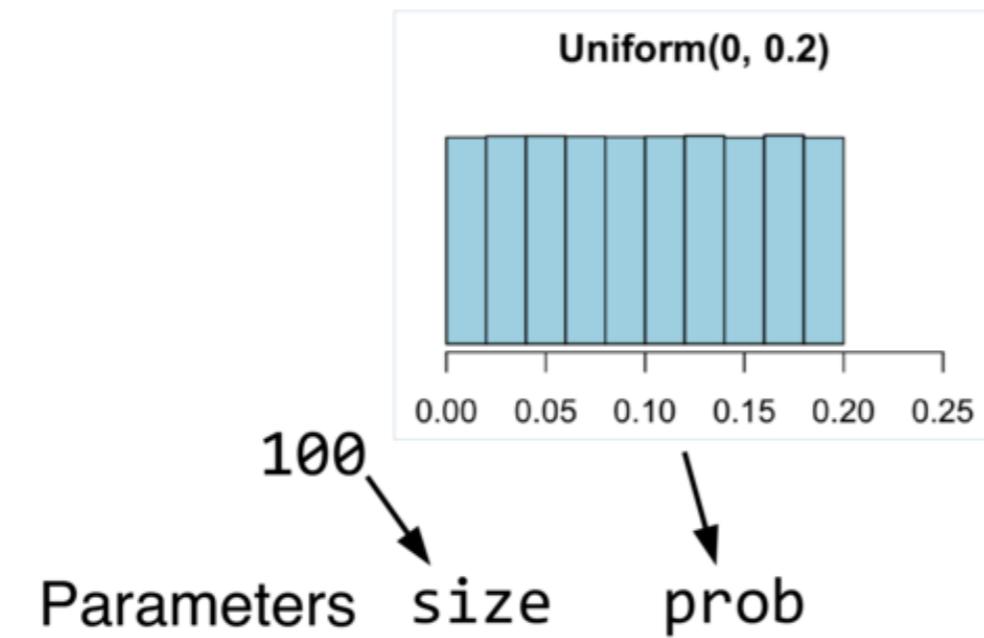


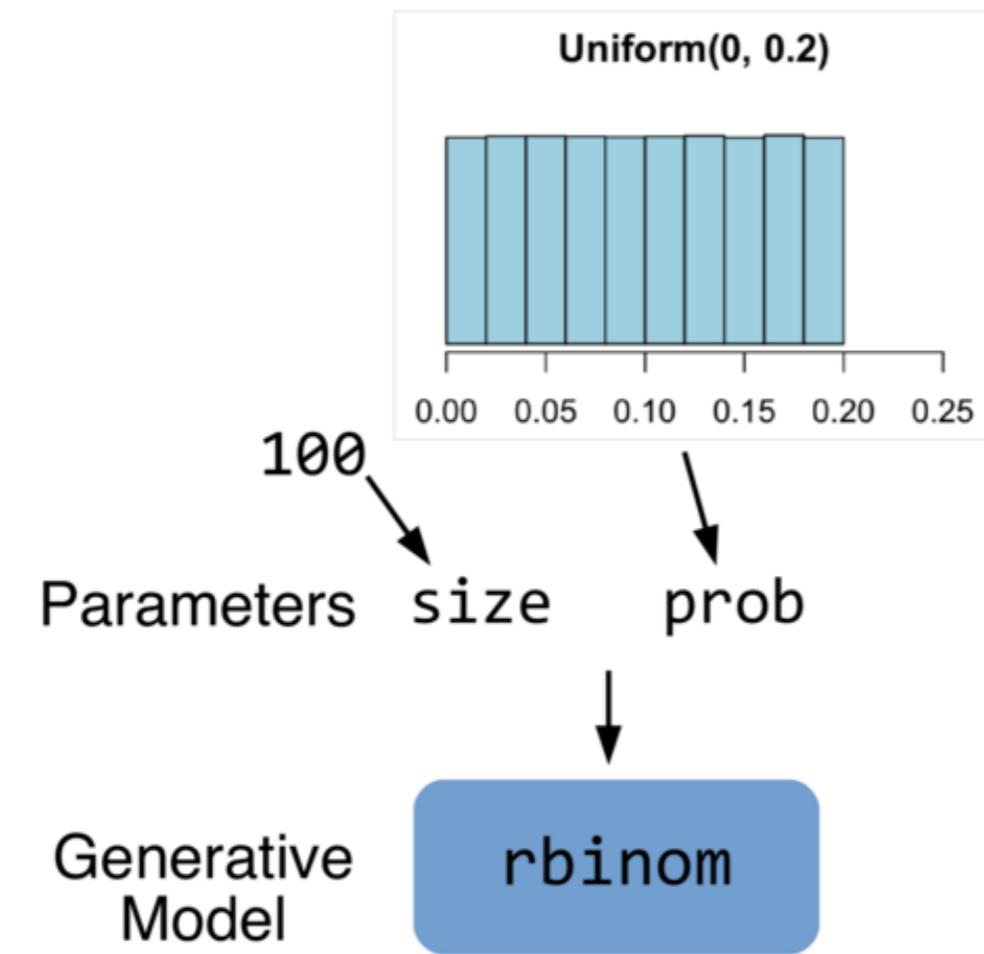


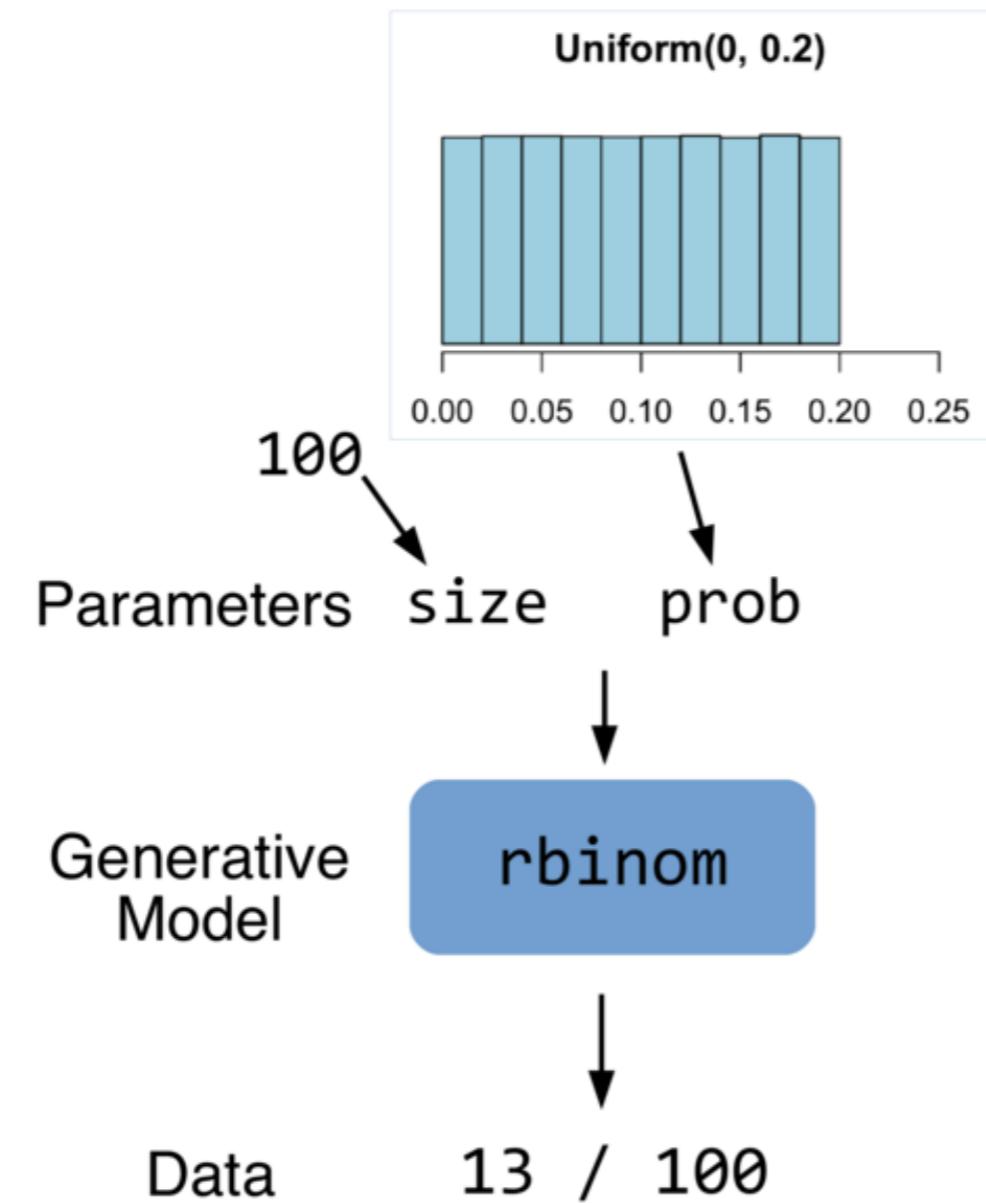


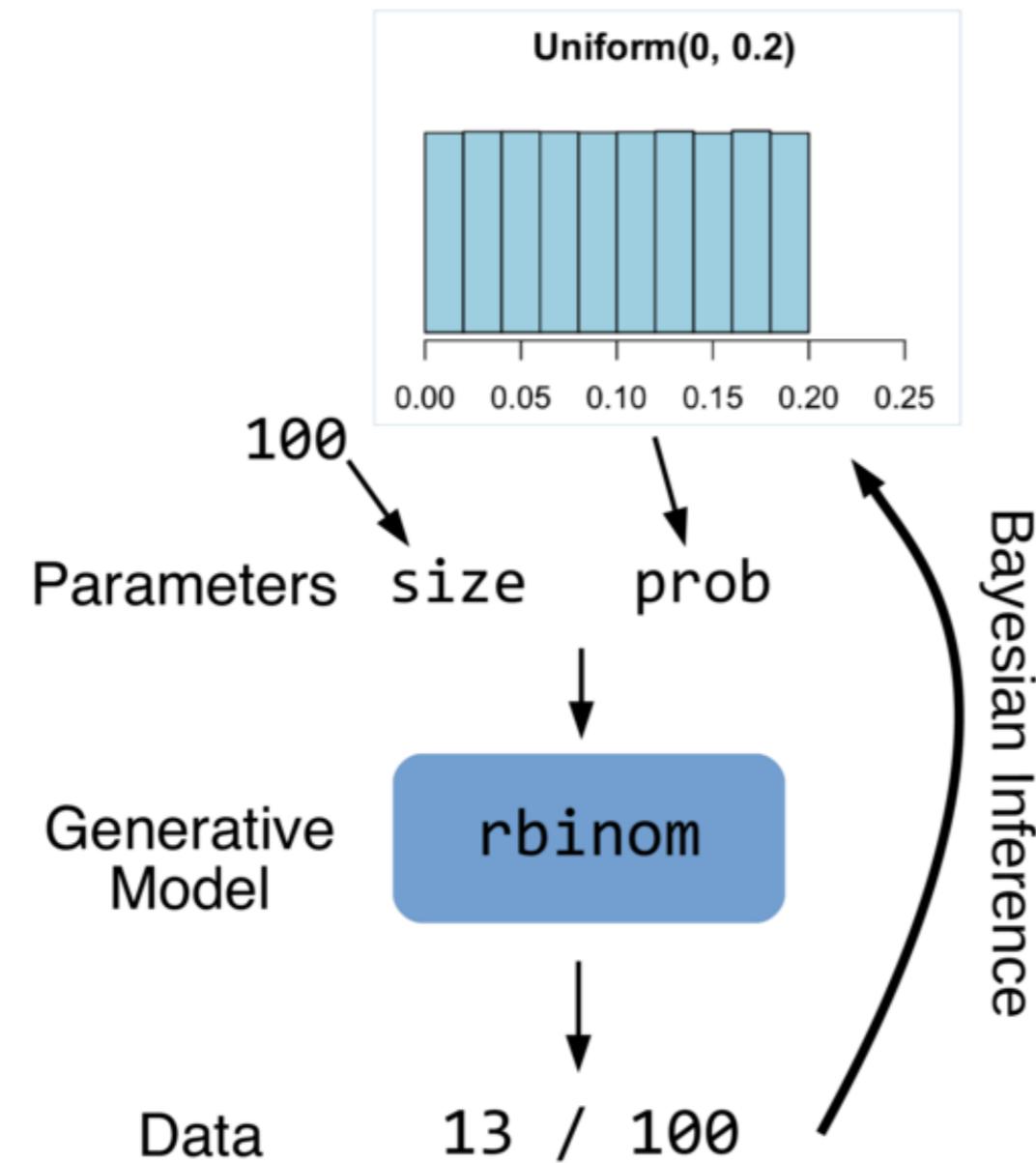


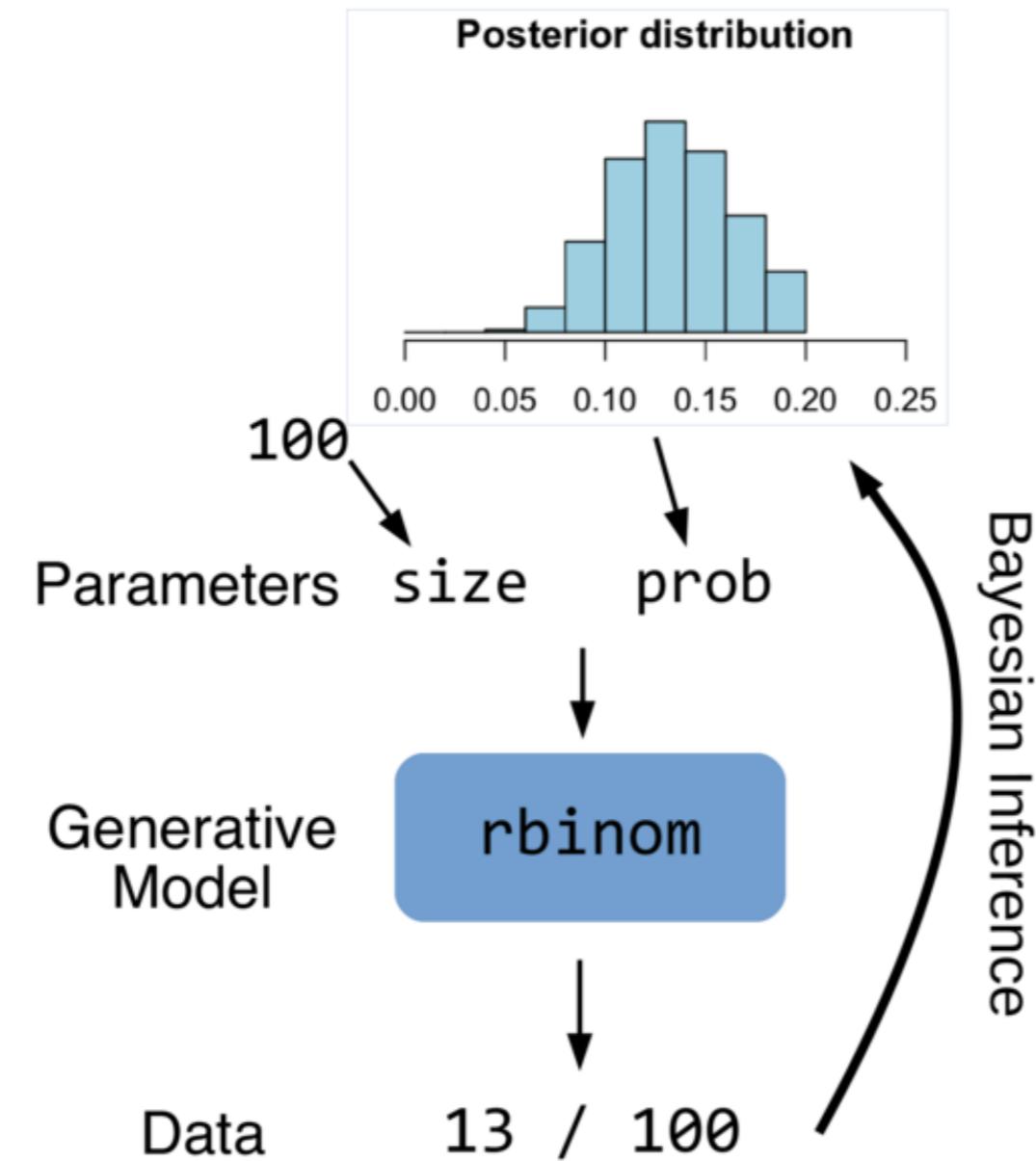


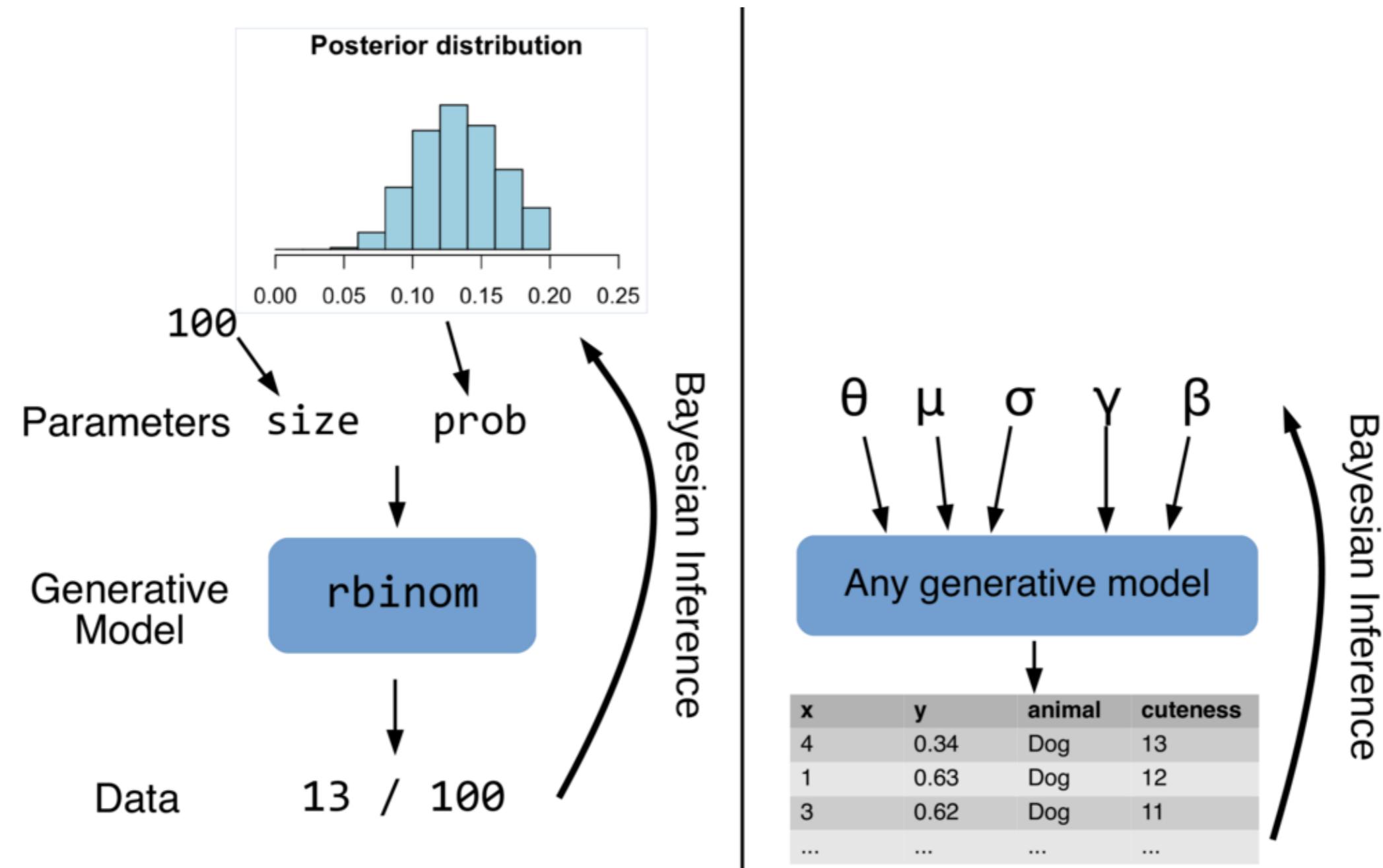


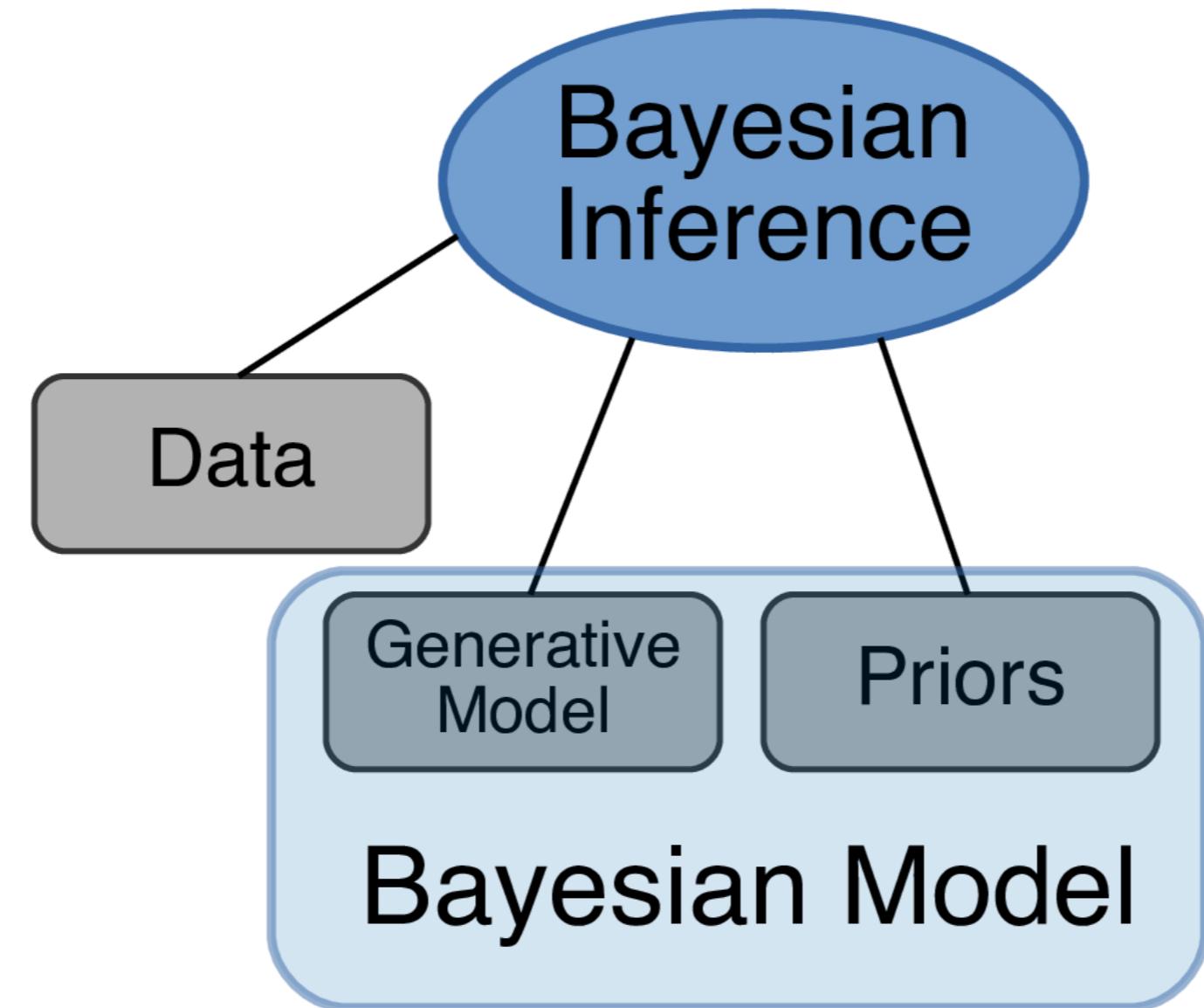


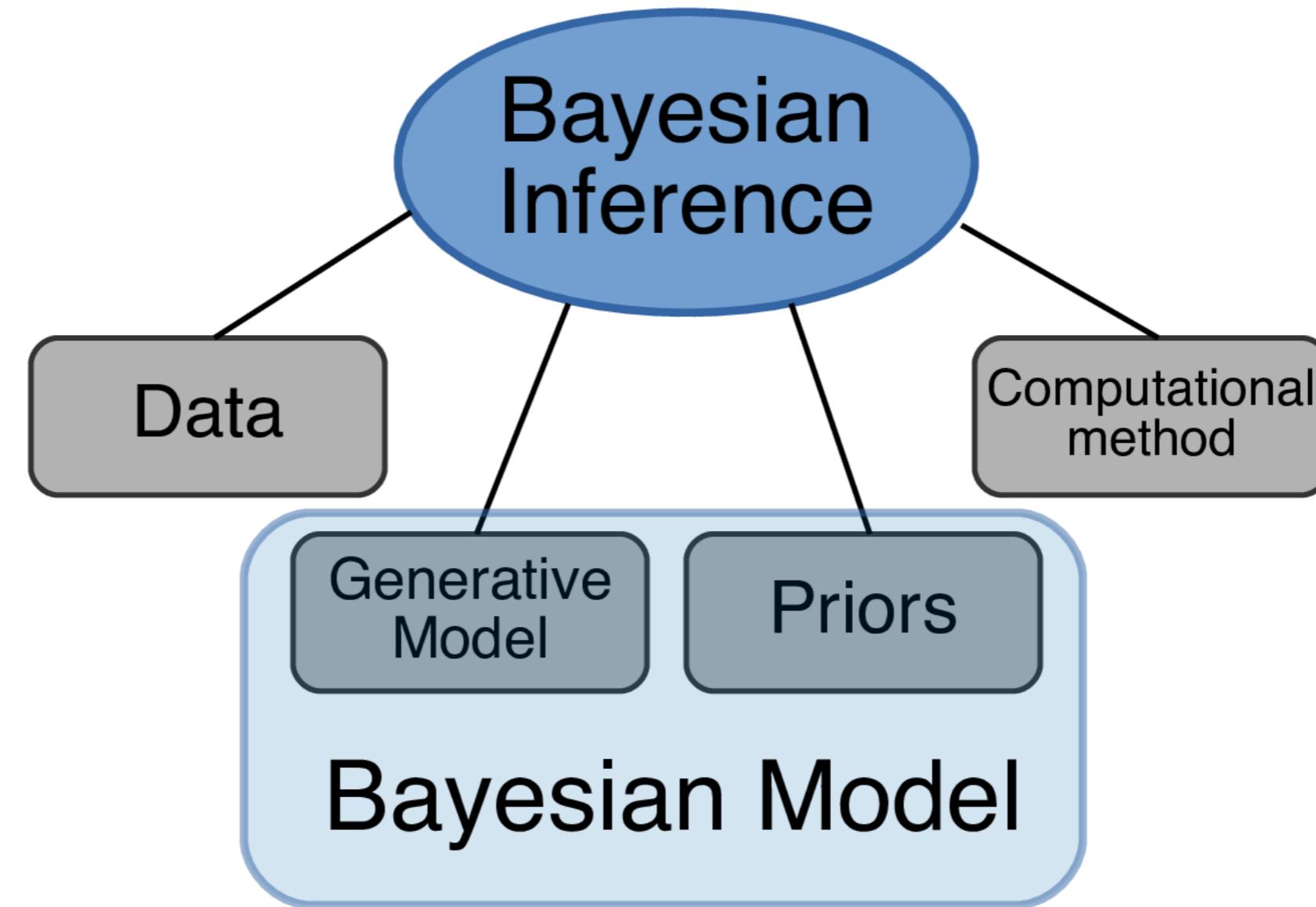












Next up: Why use Bayes?

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R