

# The parts needed for Bayesian inference

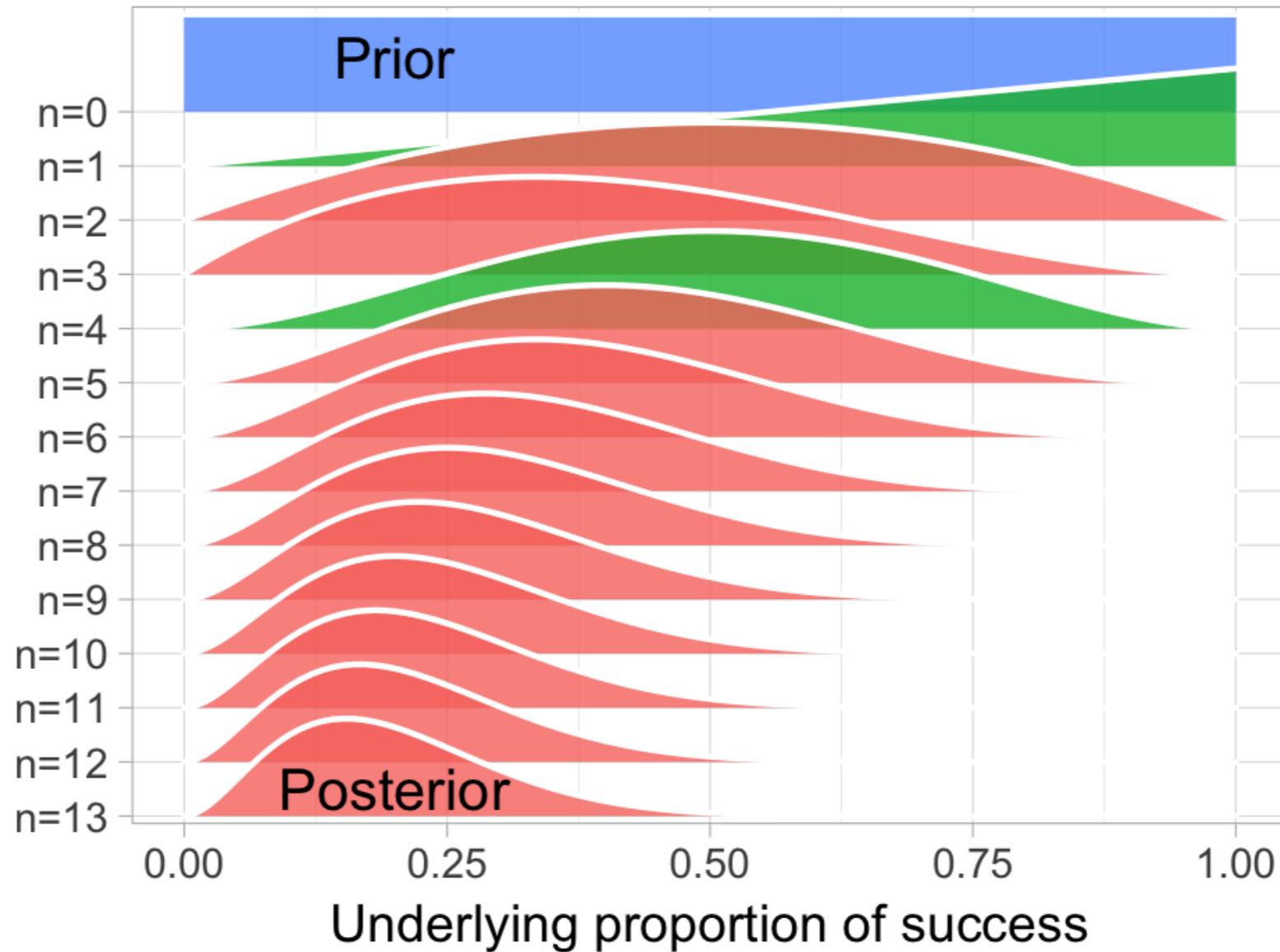
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R



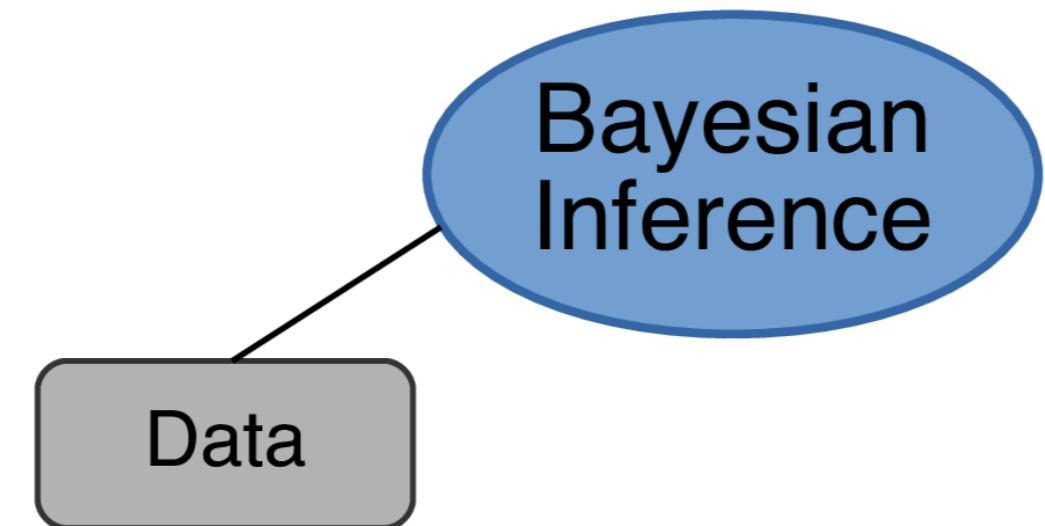
Rasmus Bååth

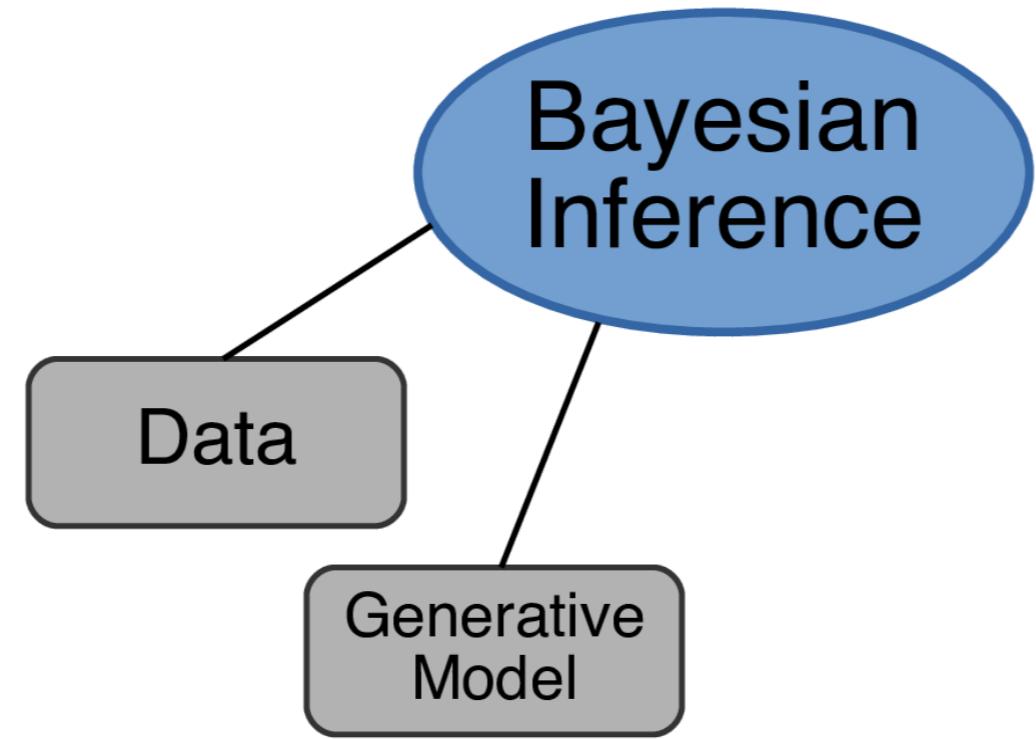
Data Scientist

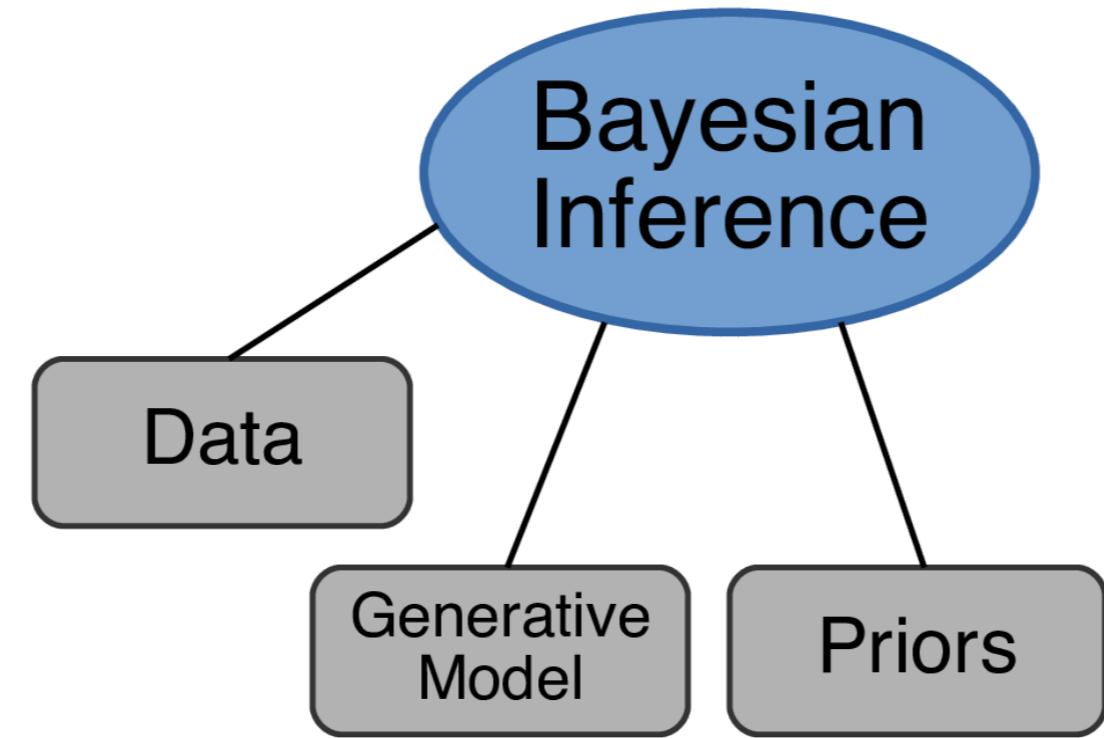
Prior Success Failure



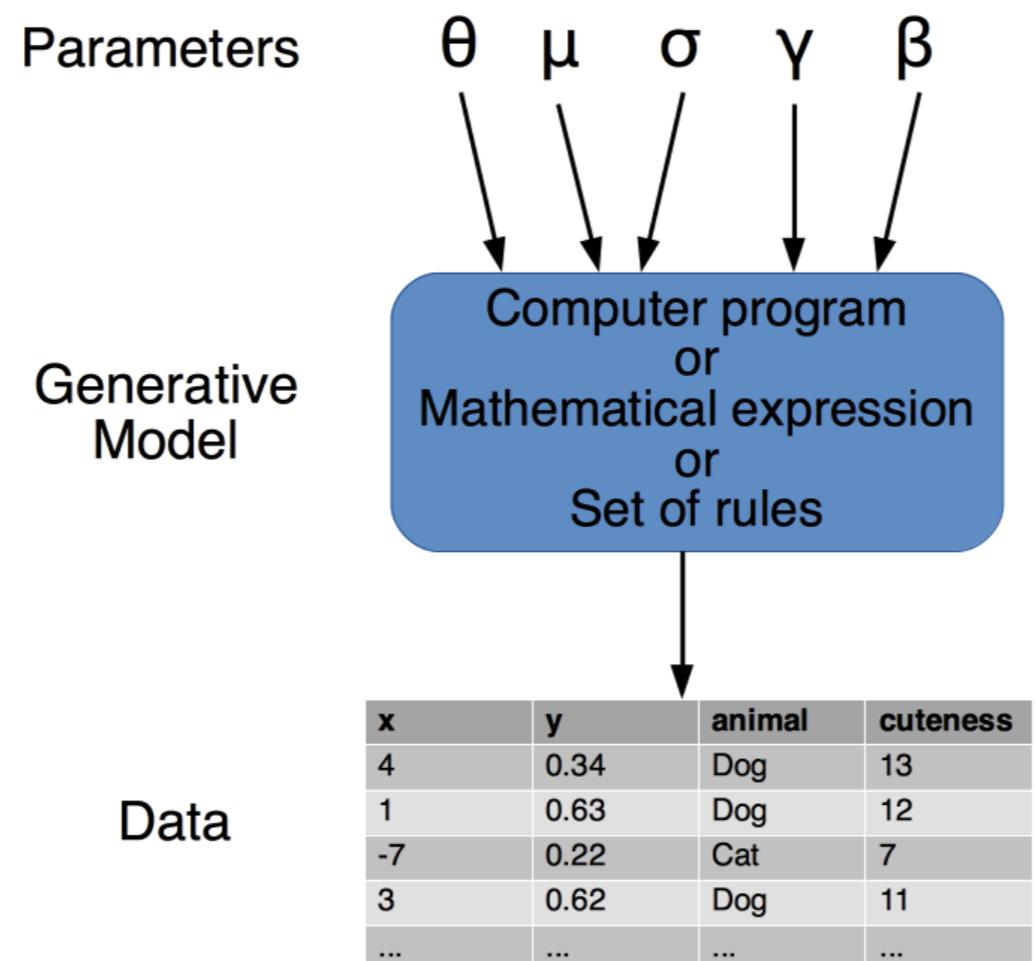
Bayesian  
Inference







# 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

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

# Generative zombie drug model

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# Parameters  
prop_success <- 0.15  
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# Simulating data  
data <- c()  
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```

```
data
```

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

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data <- as.numeric(data)
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data <- as.numeric(data)  
data
```

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

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0 0 1 0 0 0 0 0 0 0 0 0
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0 0 0 0 0 0 0 1 0 0 0 0 0
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}  
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  
              7%



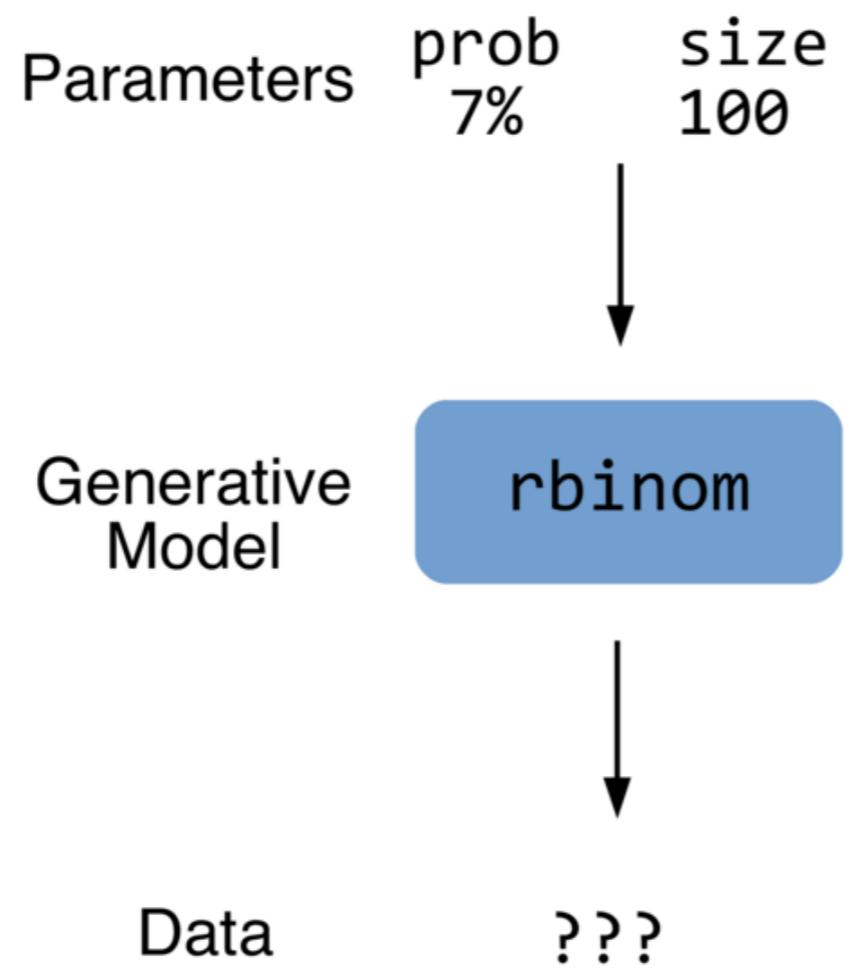
Generative  
Model

rbinom



Data

???



<sup>1</sup> [https://commons.wikimedia.org/wiki/File:The\\_Hoard\\_III\\_2\\_Flickr\\_3\\_SoulStealer.co.uk.jpg](https://commons.wikimedia.org/wiki/File:The_Hoard_III_2_Flickr_3_SoulStealer.co.uk.jpg)

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

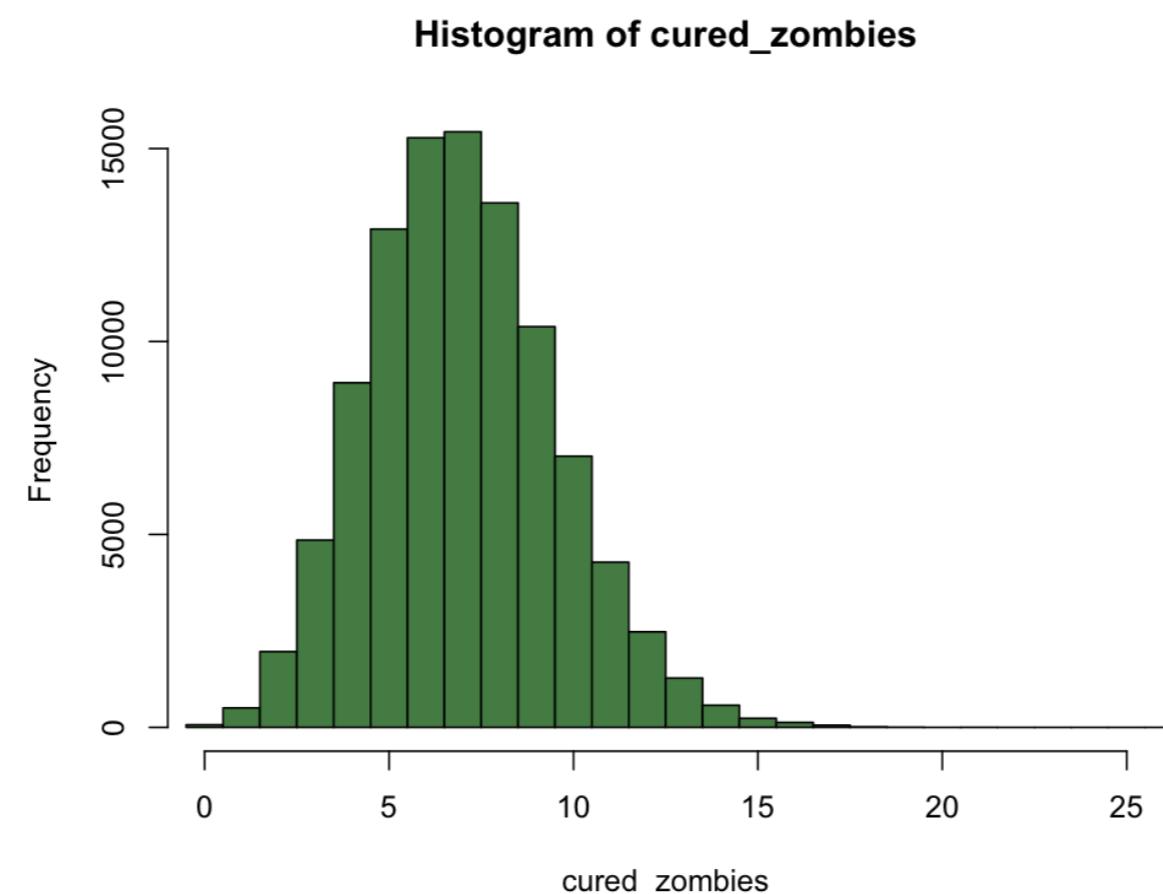
```
cured_zombies <- rbinom(n = 100000, size = 100, prob = 0.07)
```

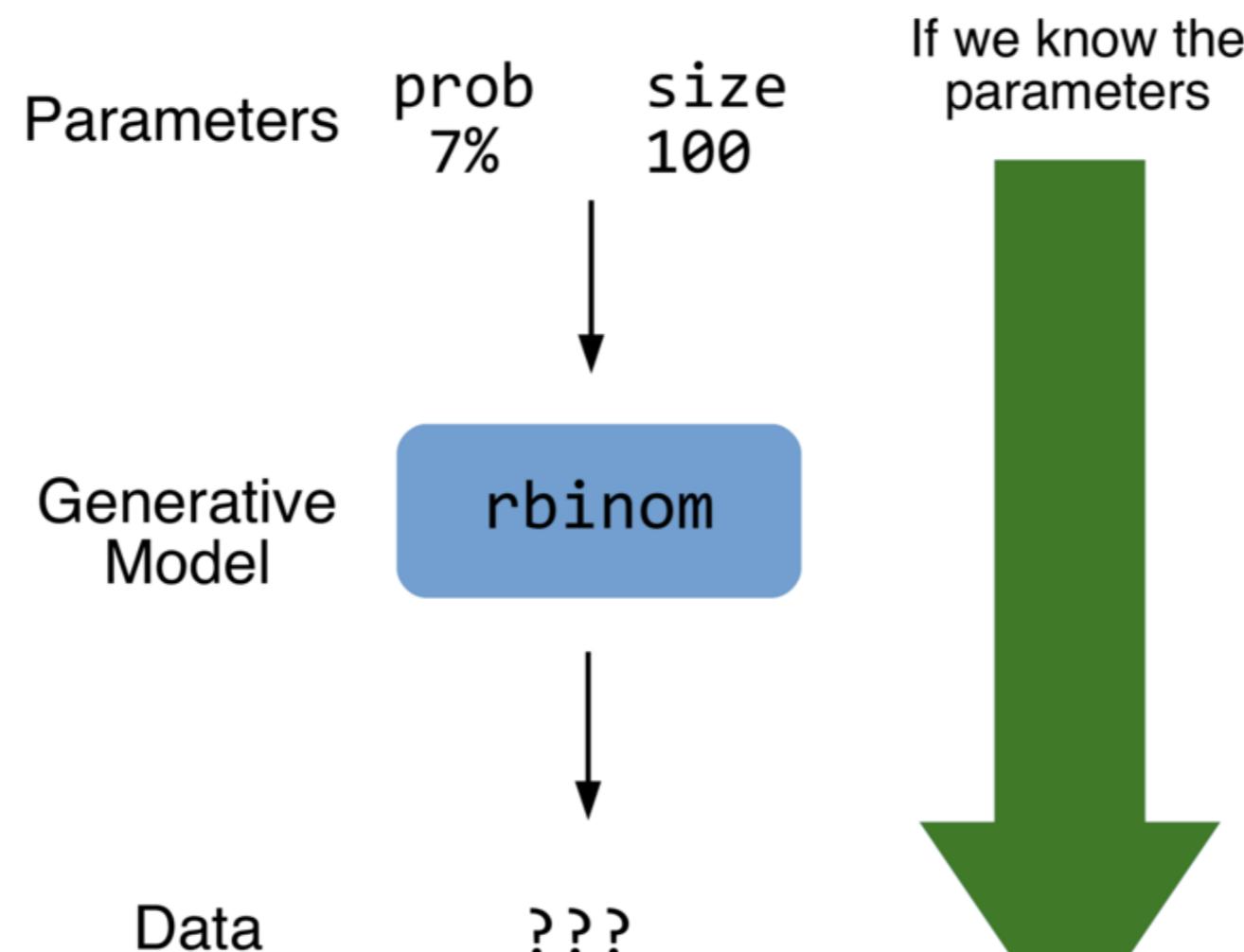
```
cured_zombies
```

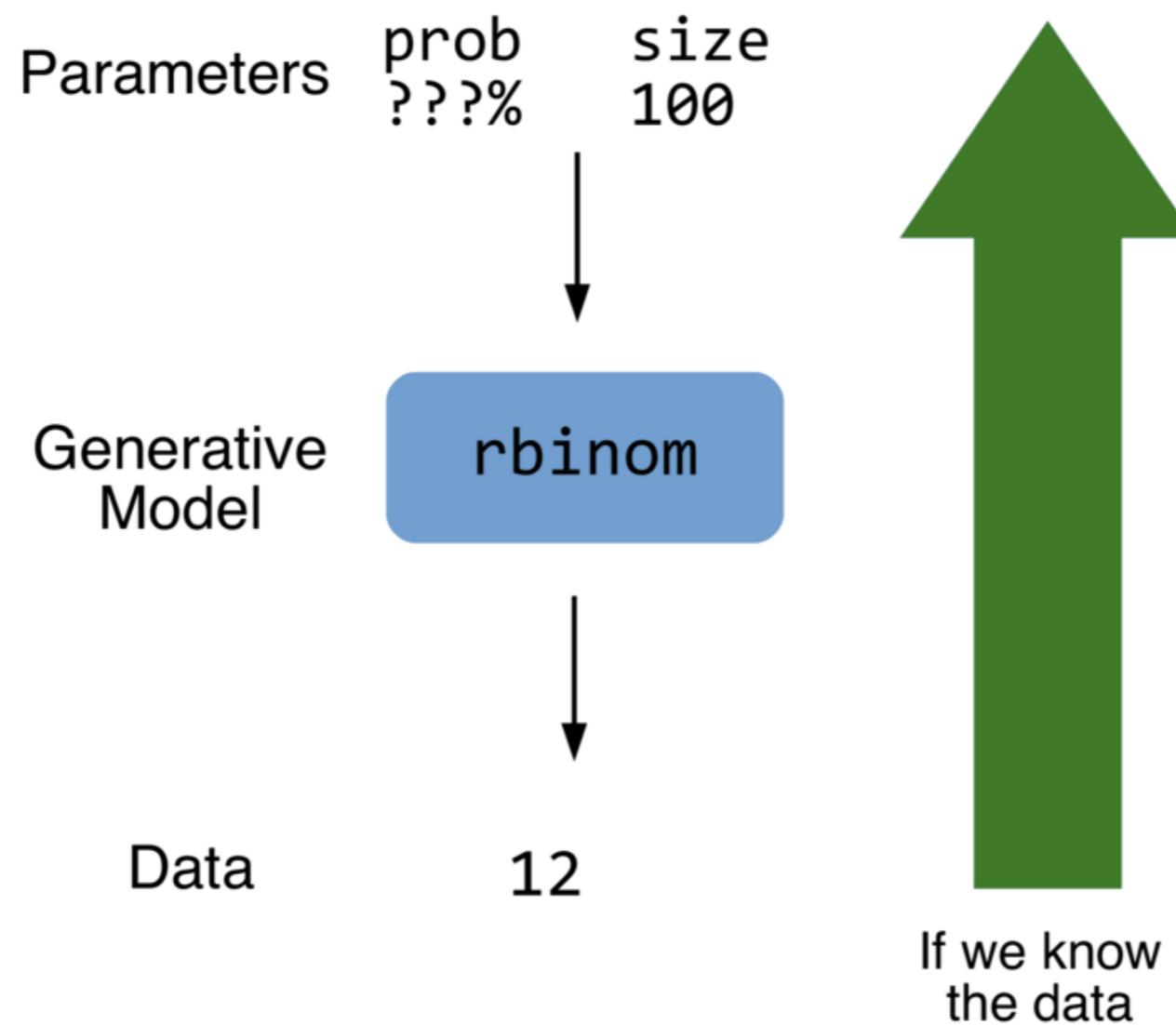
```
8   6   5   8  11  5   7   7   5   8   7  11  6   8   8  
9   9   4   7  4   8   7   5   5   6   9  14  4   4   8  
...  
...
```

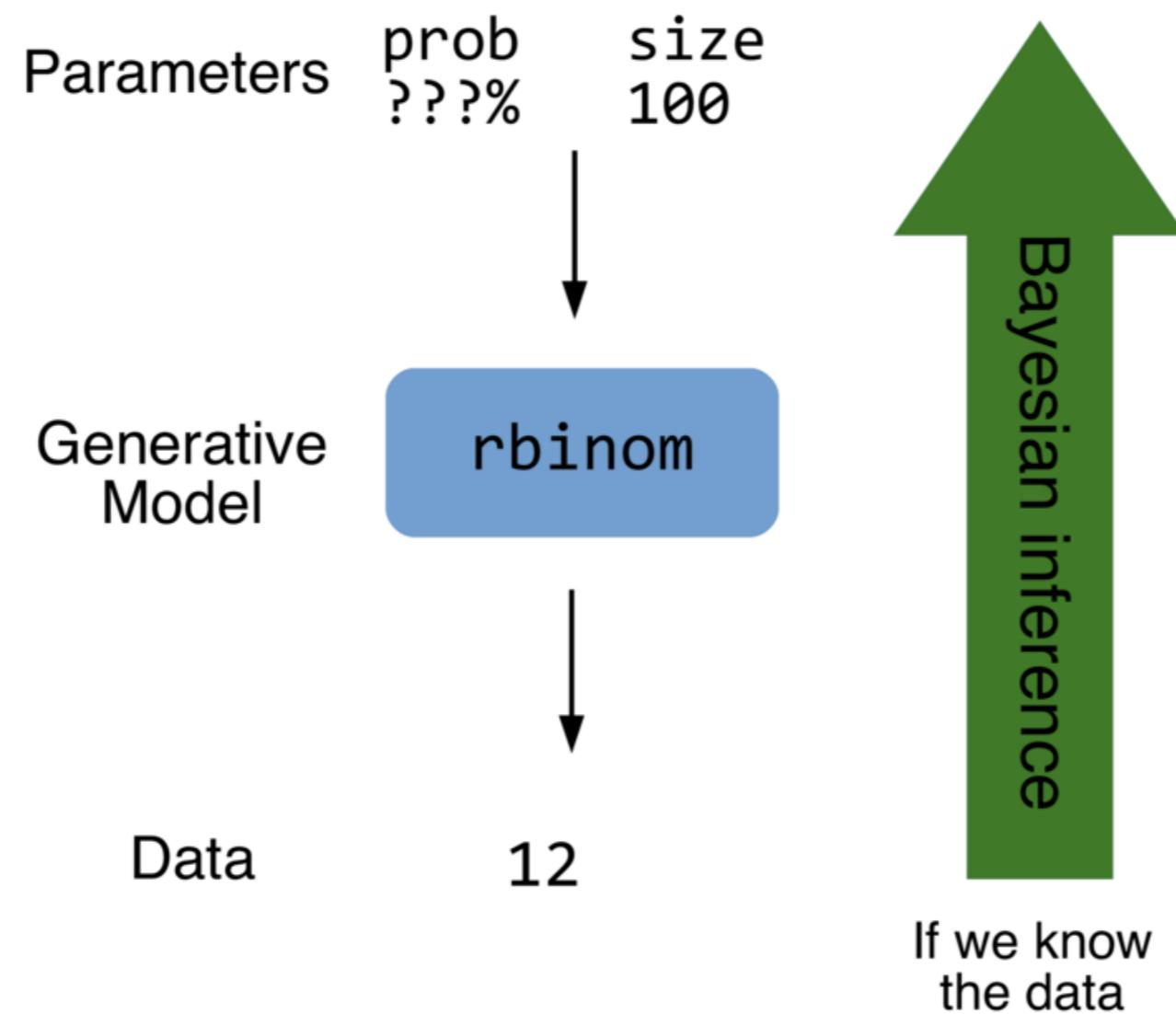
```
cured_zombies <- rbinom(n = 100000, size = 100, prob = 0.07)
```

```
hist(cured_zombies)
```

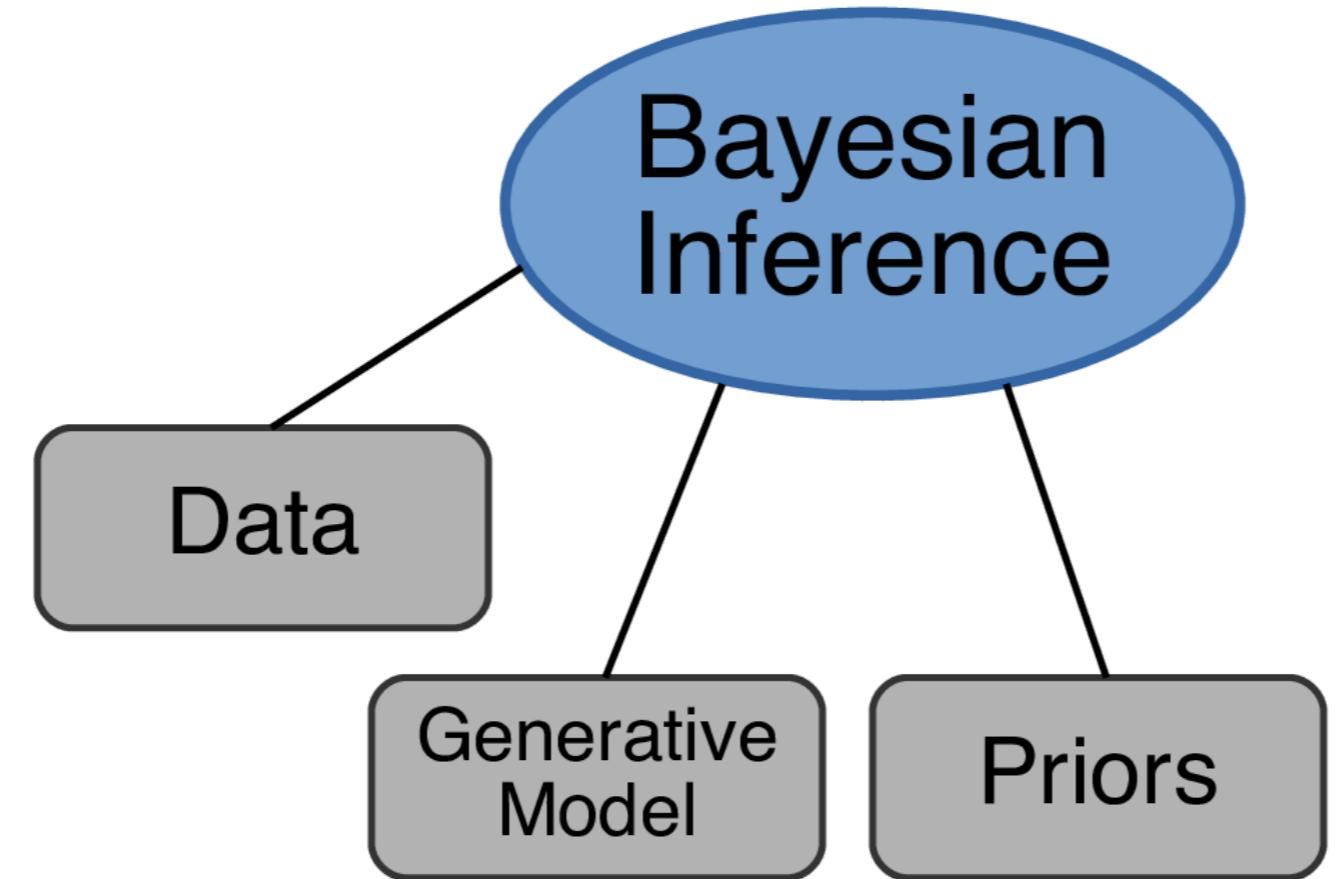


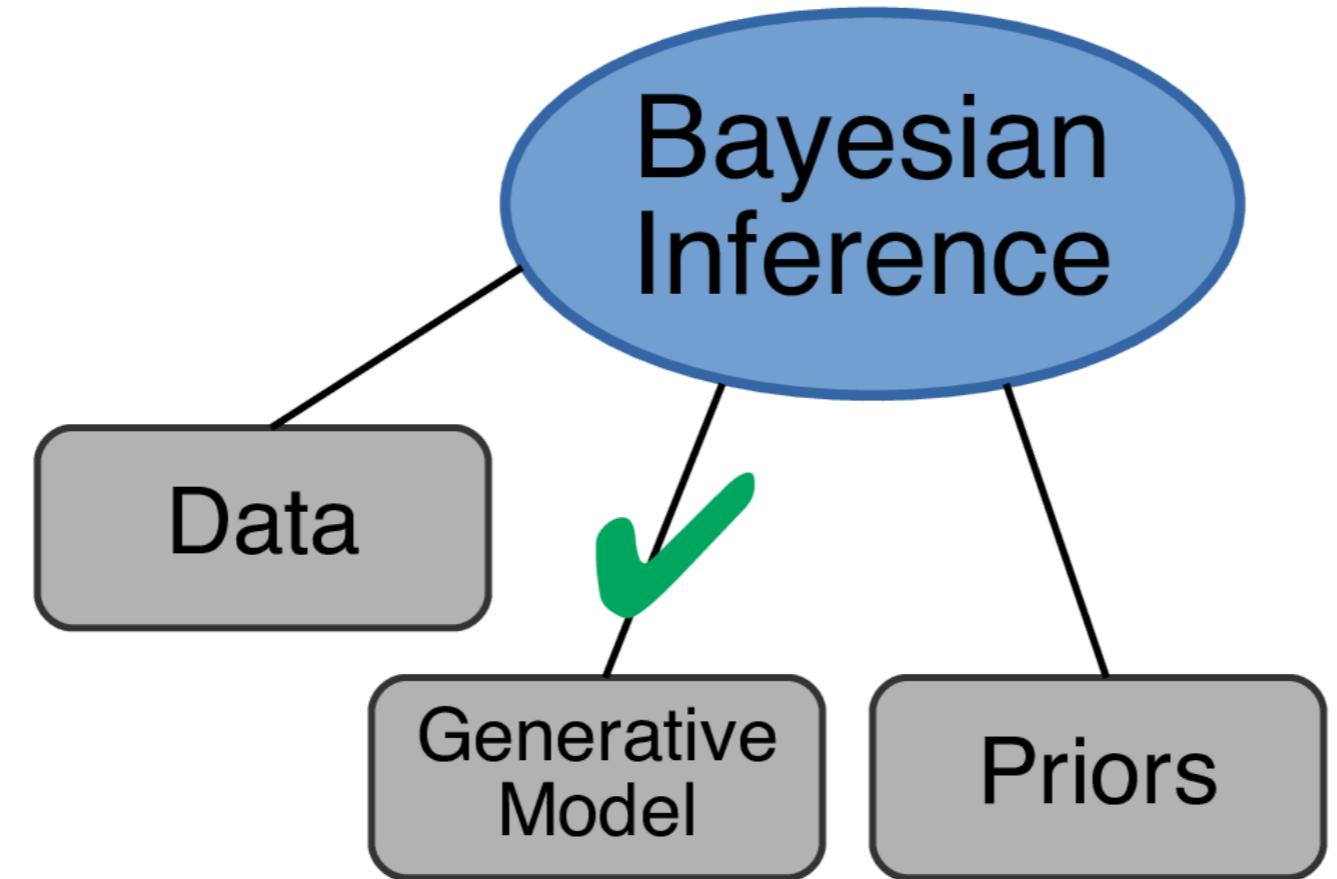






If we know  
the data







<sup>1</sup> [https://commons.wikimedia.org/wiki/File:The\\_Hoard\\_III\\_2\\_Flickr\\_3\\_SoulStealer.co.uk.jpg](https://commons.wikimedia.org/wiki/File:The_Hoard_III_2_Flickr_3_SoulStealer.co.uk.jpg)





# How many visitors?

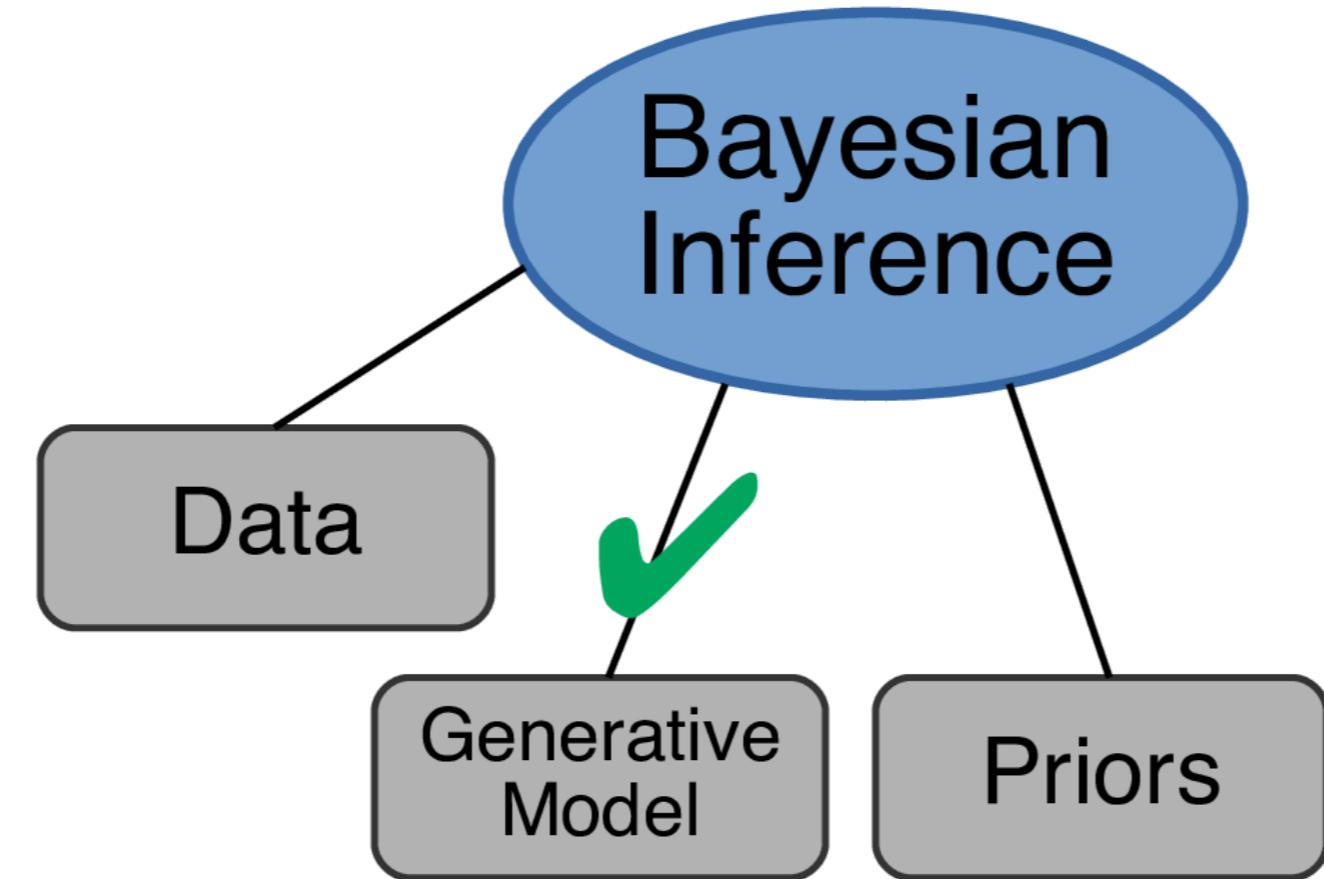
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

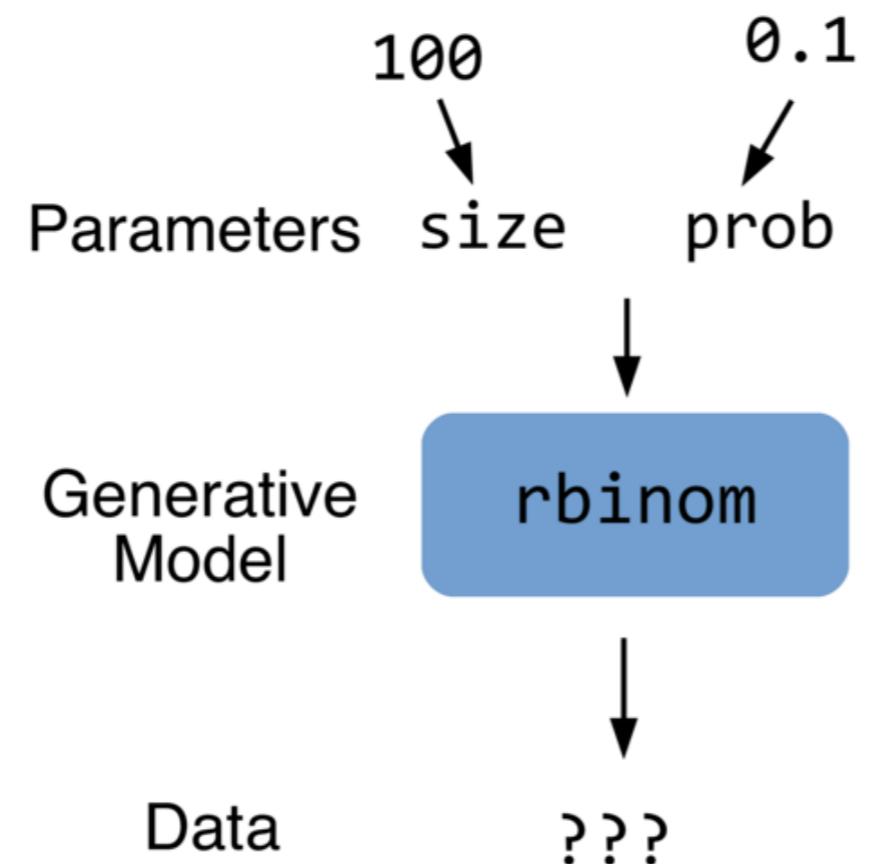
# One more part

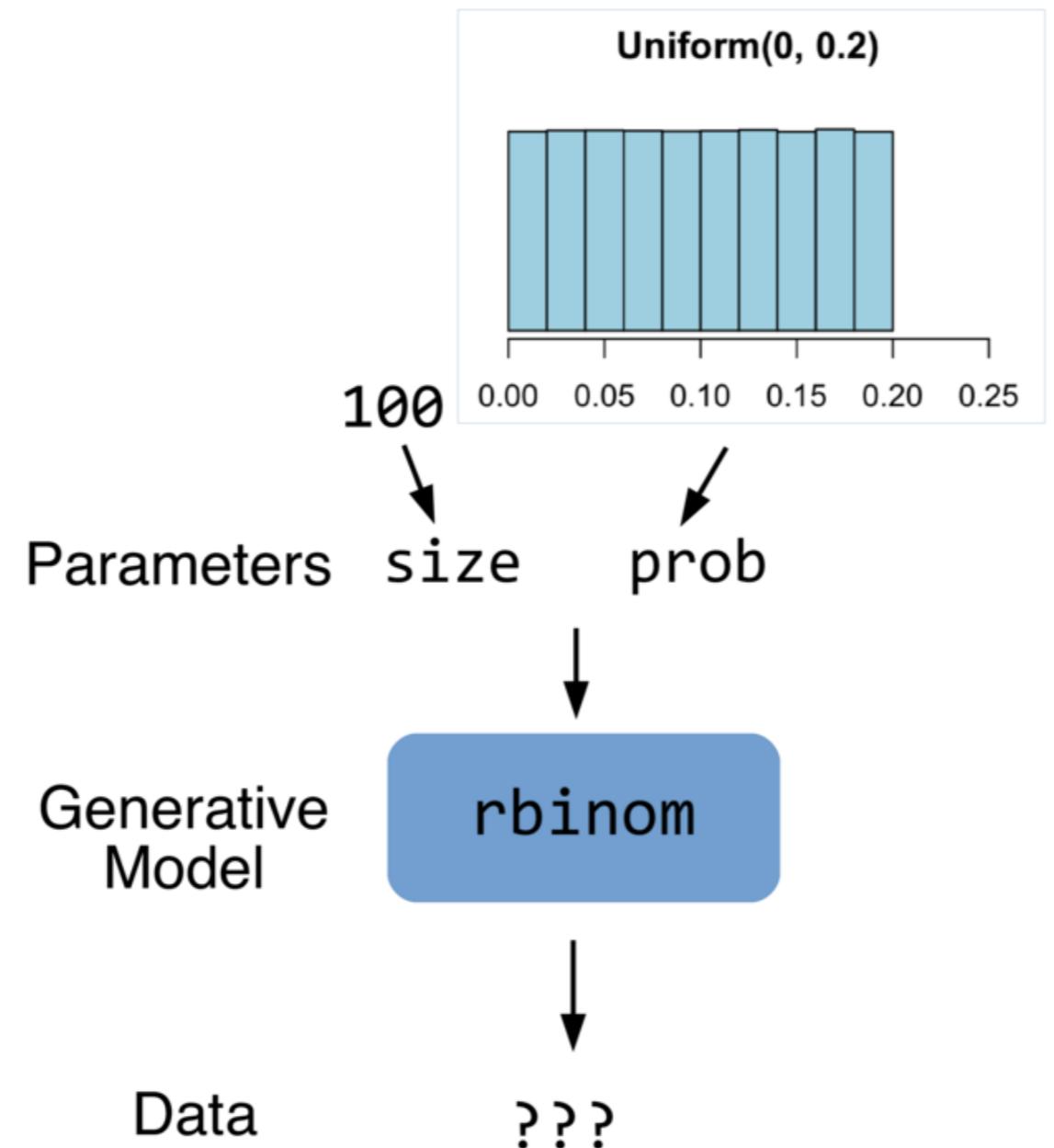
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R



Rasmus Bååth  
Data Scientist







# 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

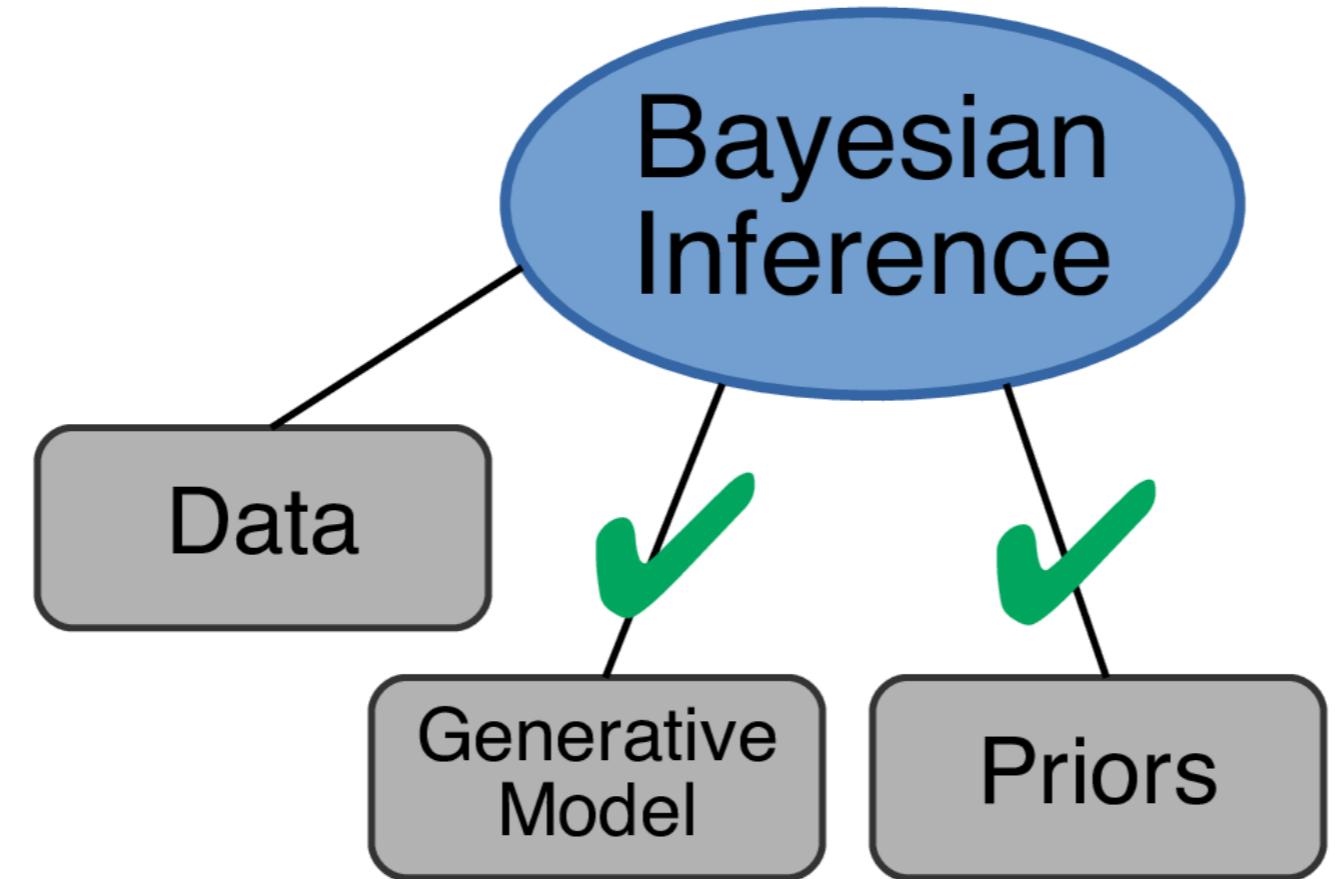
# Bayesian models and conditioning

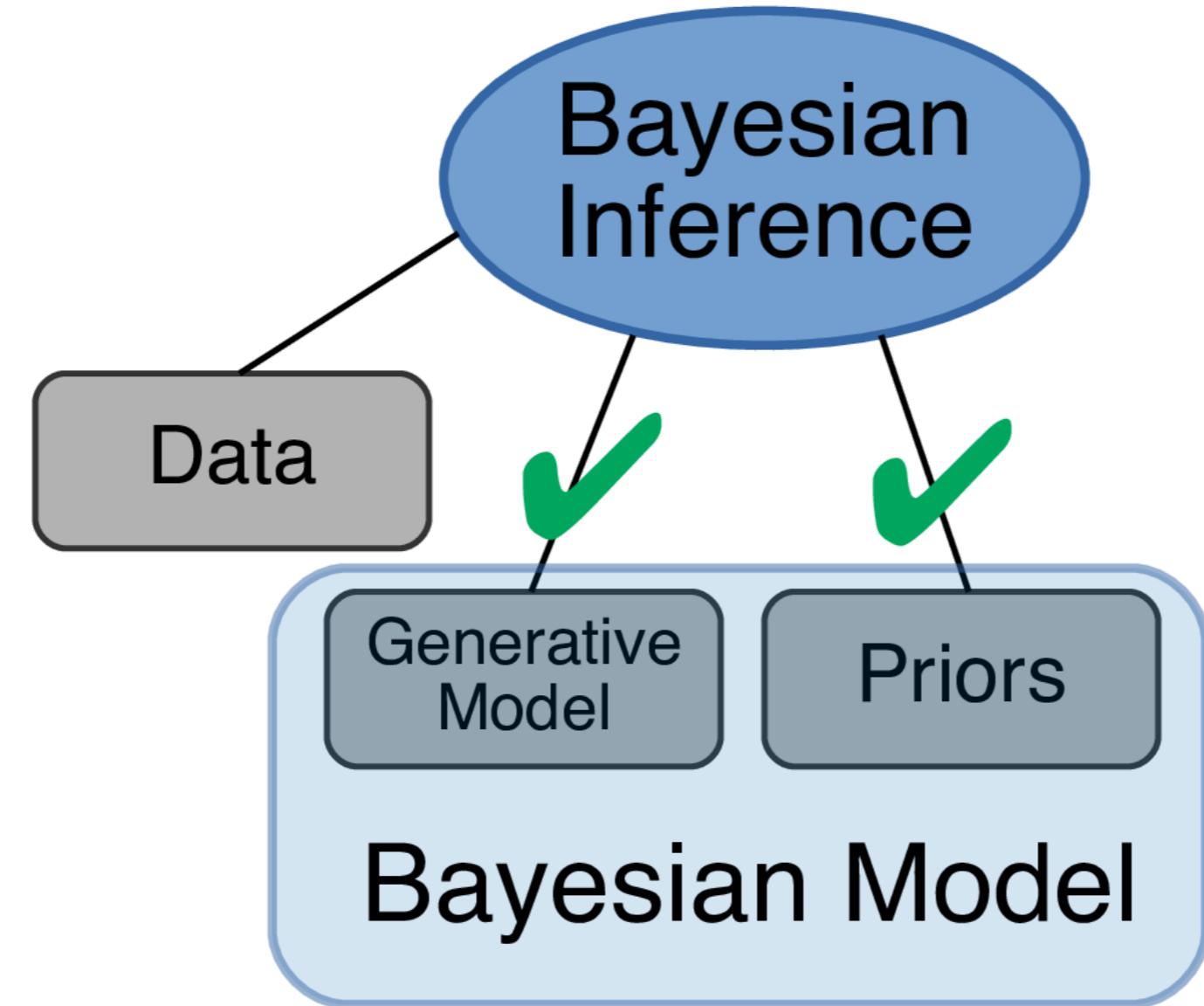
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R



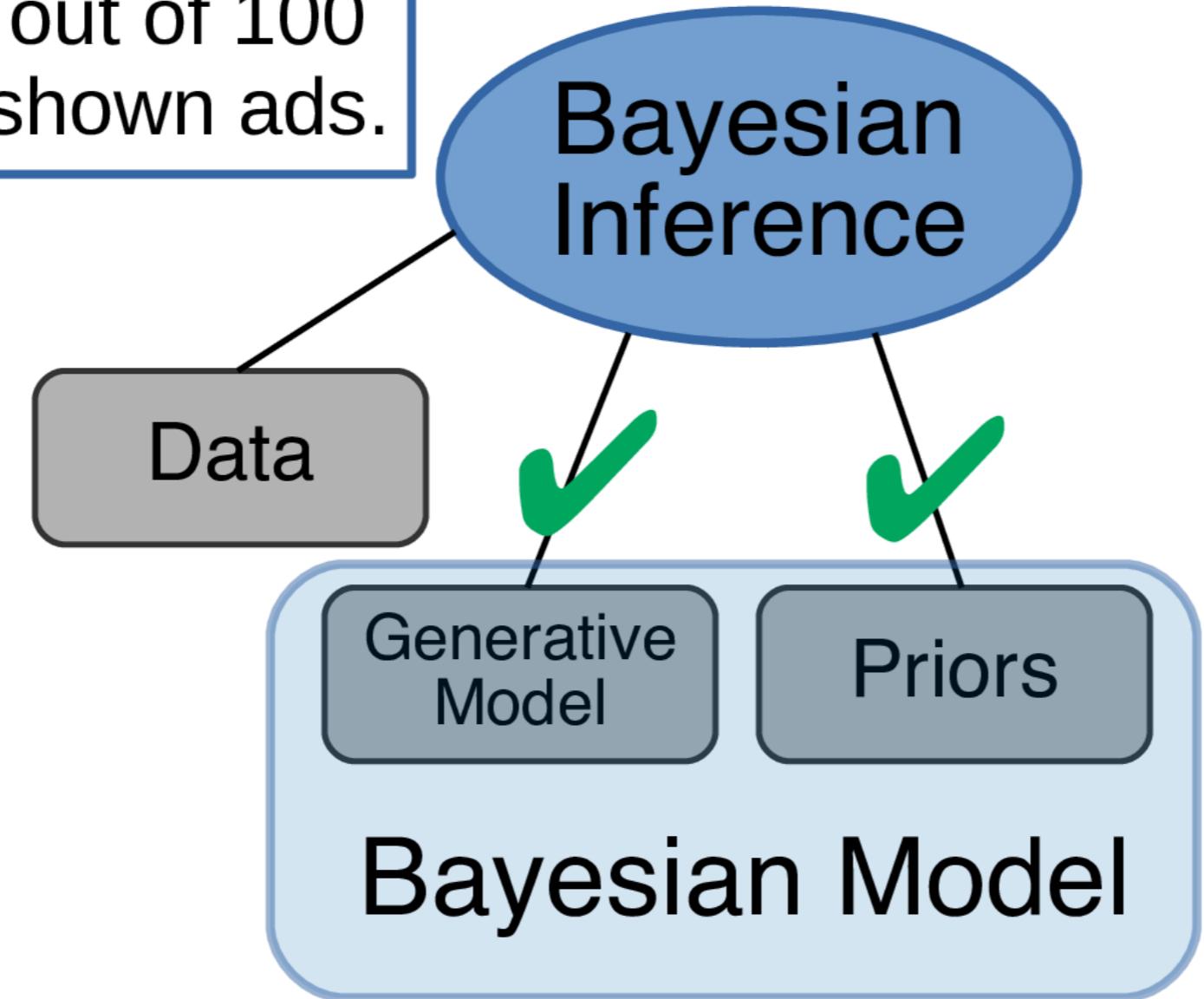
Rasmus Bååth

Data Scientist

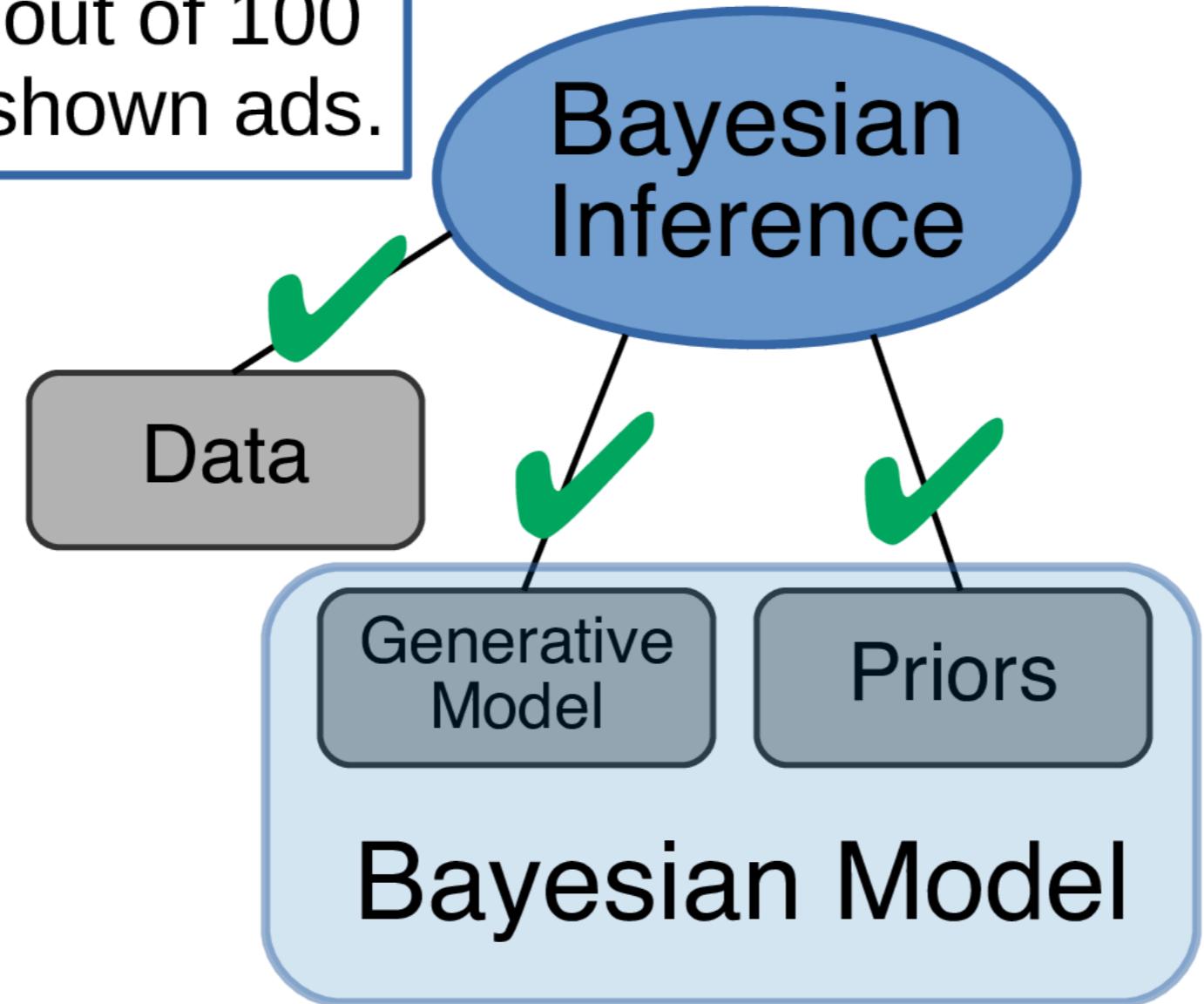




13 clicked  
out of 100  
shown ads.



13 clicked  
out of 100  
shown ads.

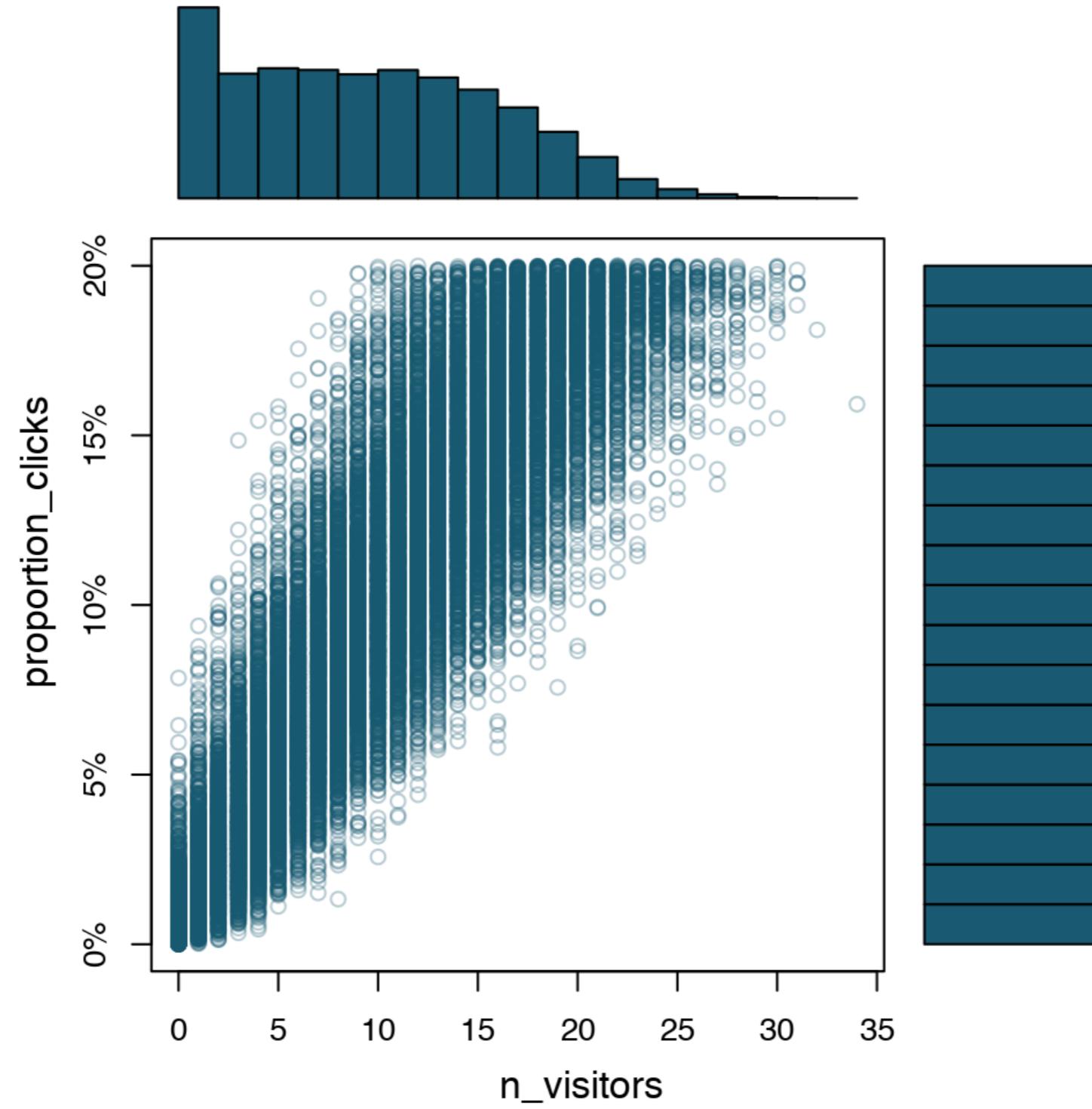


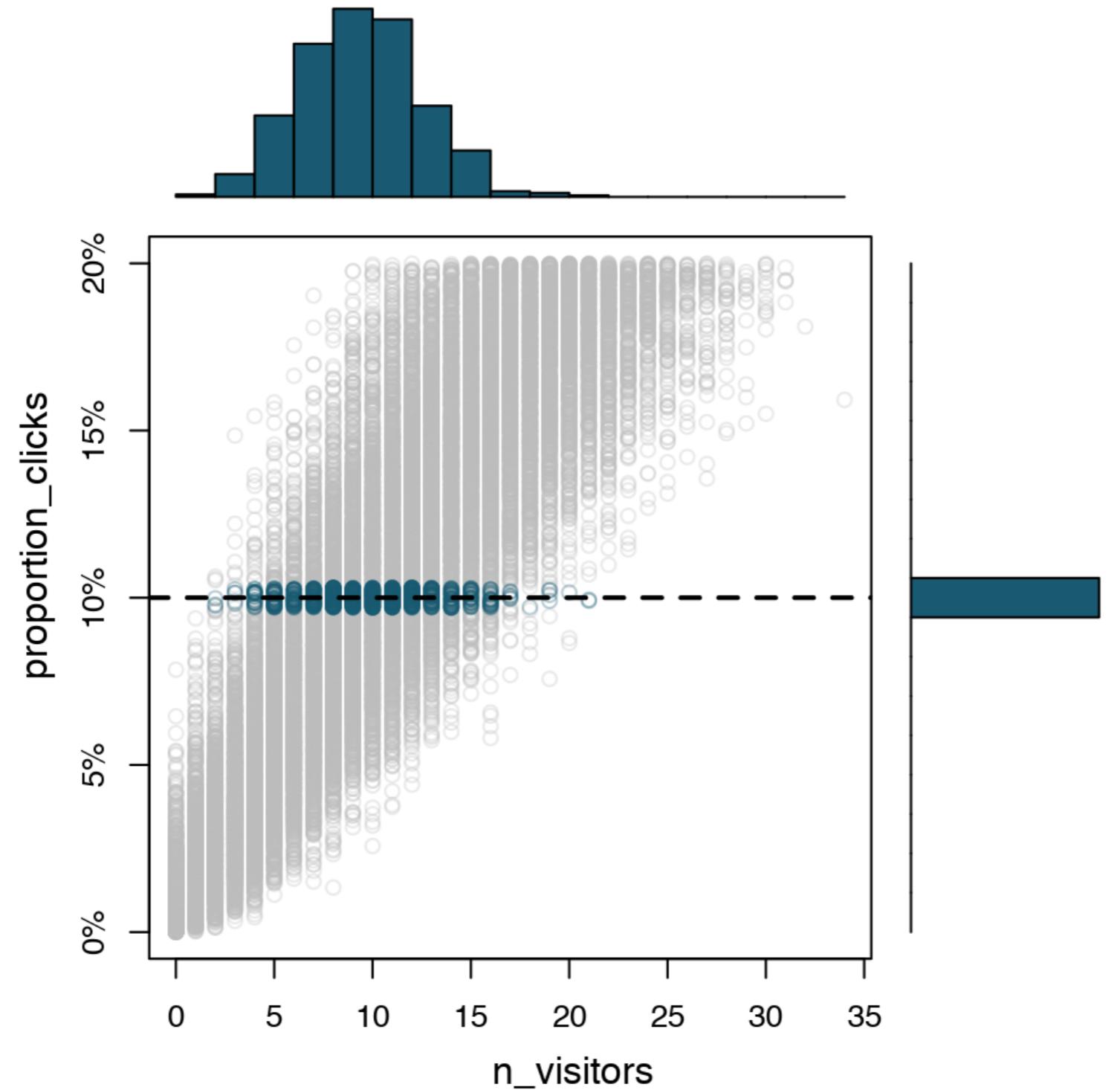
```
n_samples <- 100000  
n_ads_shown <- 100  
proportion_clicks <- runif(n_samples, min = 0.0, max = 0.2)  
n_visitors <- rbinom(n = n_samples, size = n_ads_shown,  
                      prob = proportion_clicks)
```

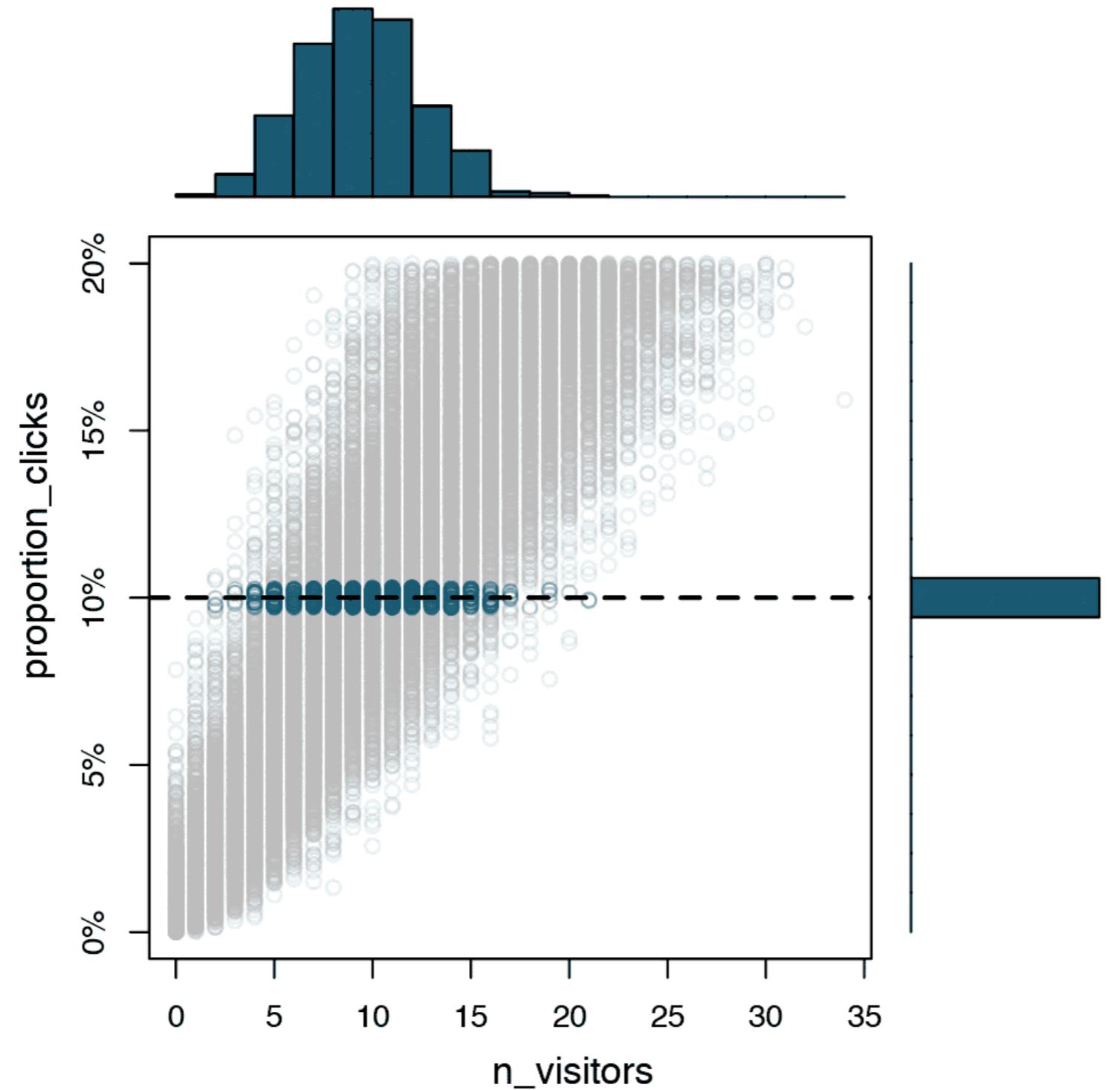
```
n_samples <- 100000
n_ads_shown <- 100
proportion_clicks <- runif(n_samples, min = 0.0, max = 0.2)
n_visitors <- rbinom(n = n_samples, size = n_ads_shown,
                      prob = proportion_clicks)
prior <- data.frame(proportion_clicks, n_visitors)
```

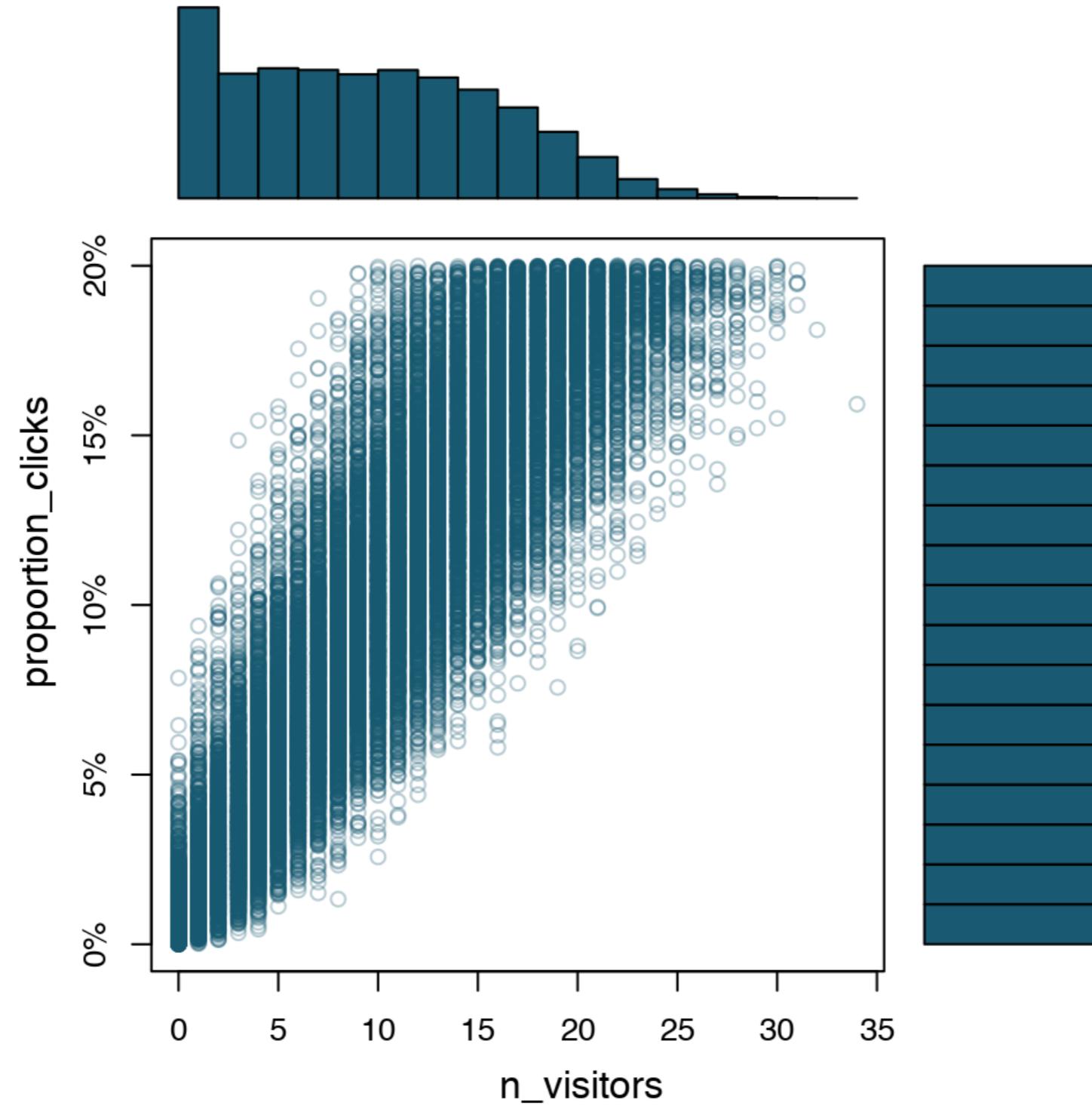
prior

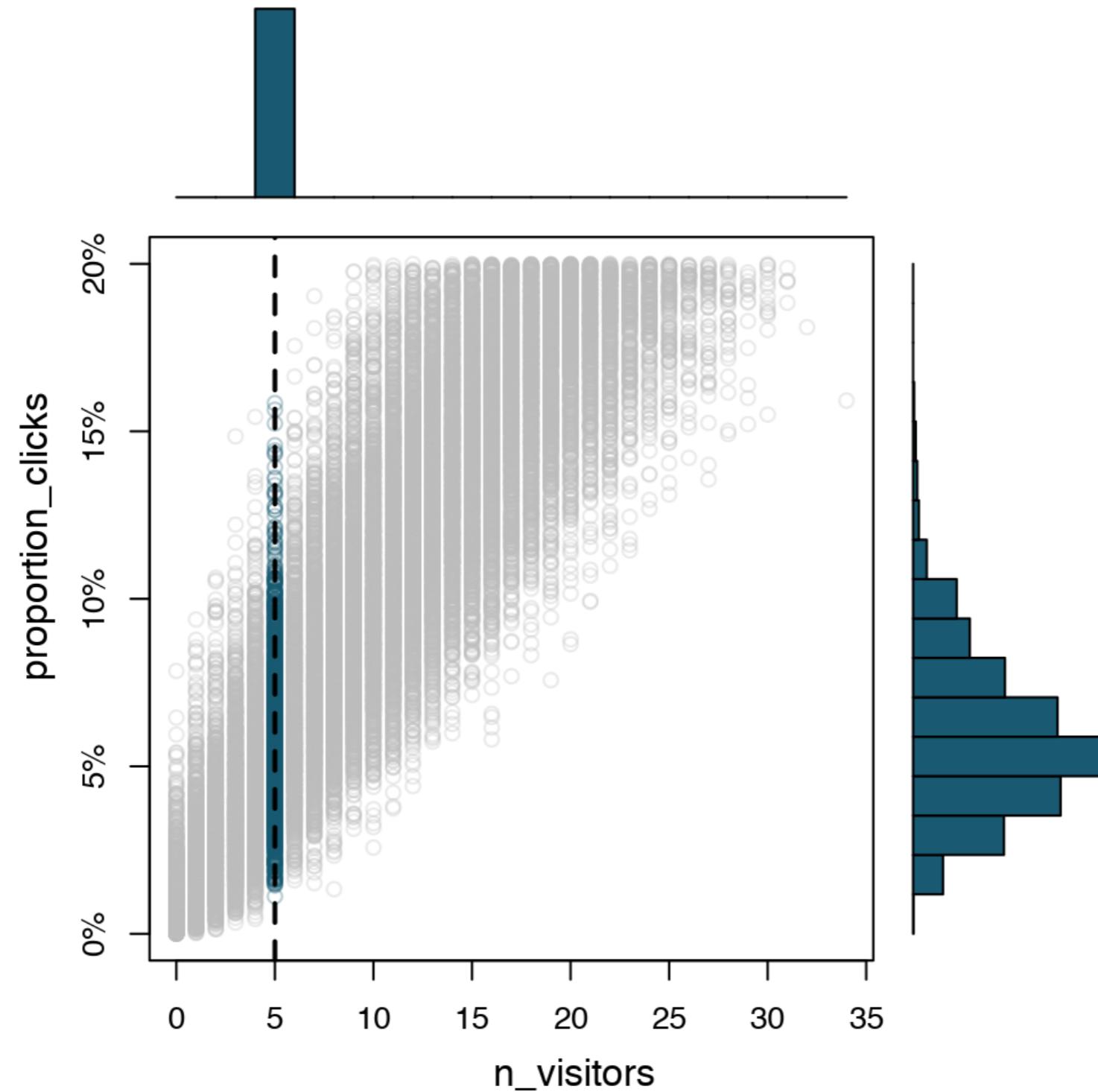
	proportion_clicks	n_visitors
1	0.12	10
2	0.04	3
3	0.11	14
4	0.15	14
5	0.15	12
6	0.16	13
7	0.04	6
8	0.04	3
9	0.09	10
10	0.04	3
11	0.08	8
12	0.13	12
13	0.02	3
14	0.18	19
15	0.04	5
16	0.10	10
...	...	...

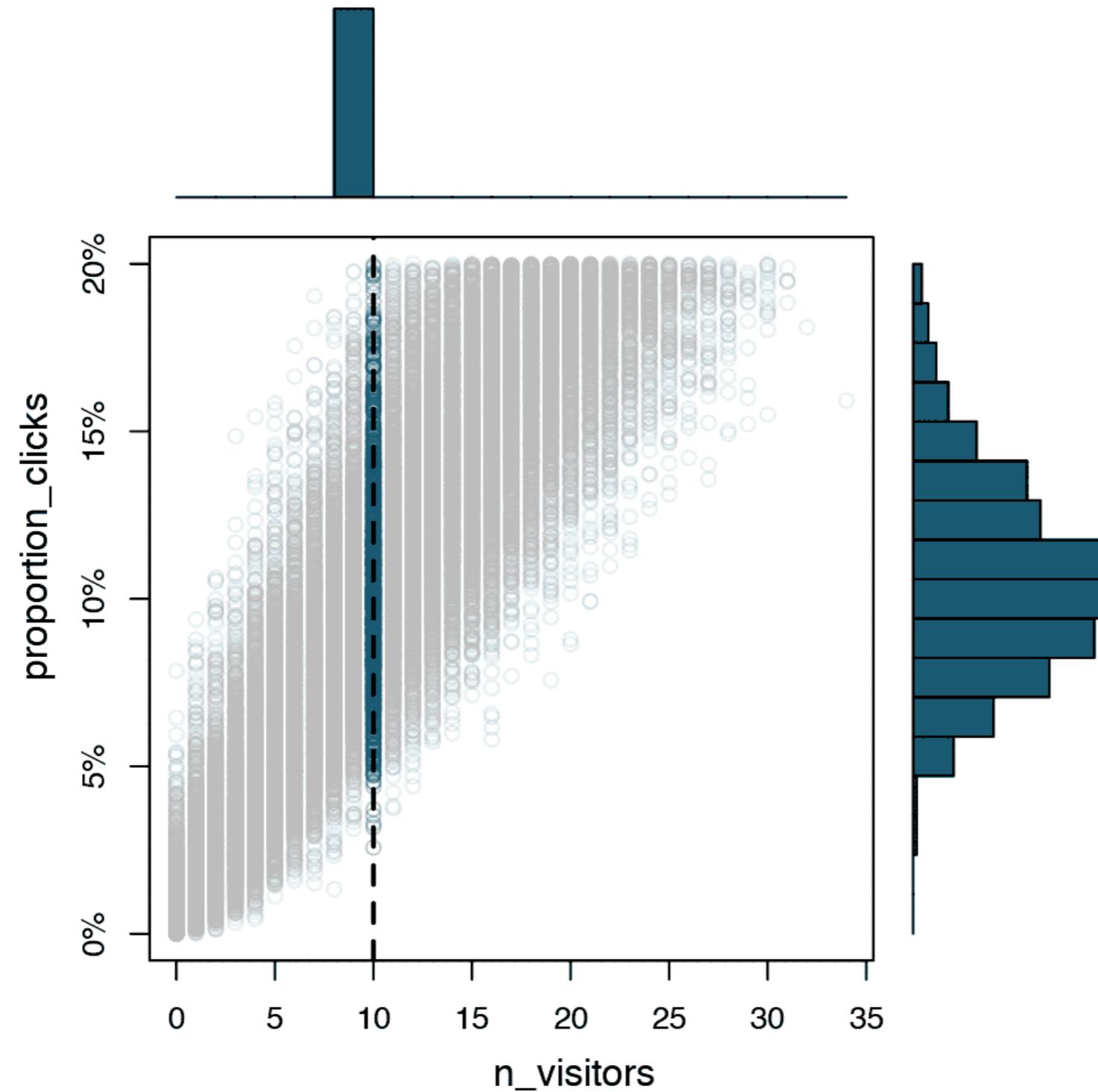












# The essence of Bayesian inference

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

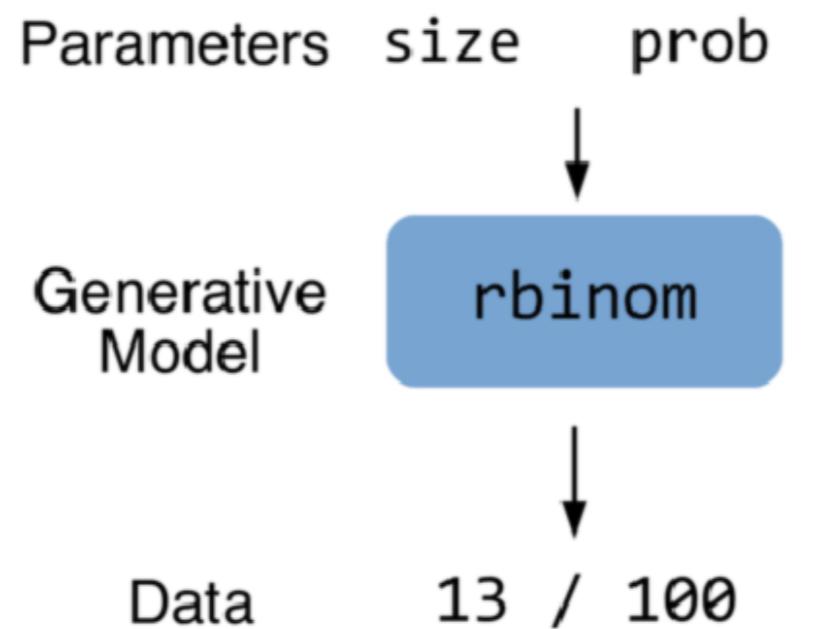
# Bayesian inference, again!

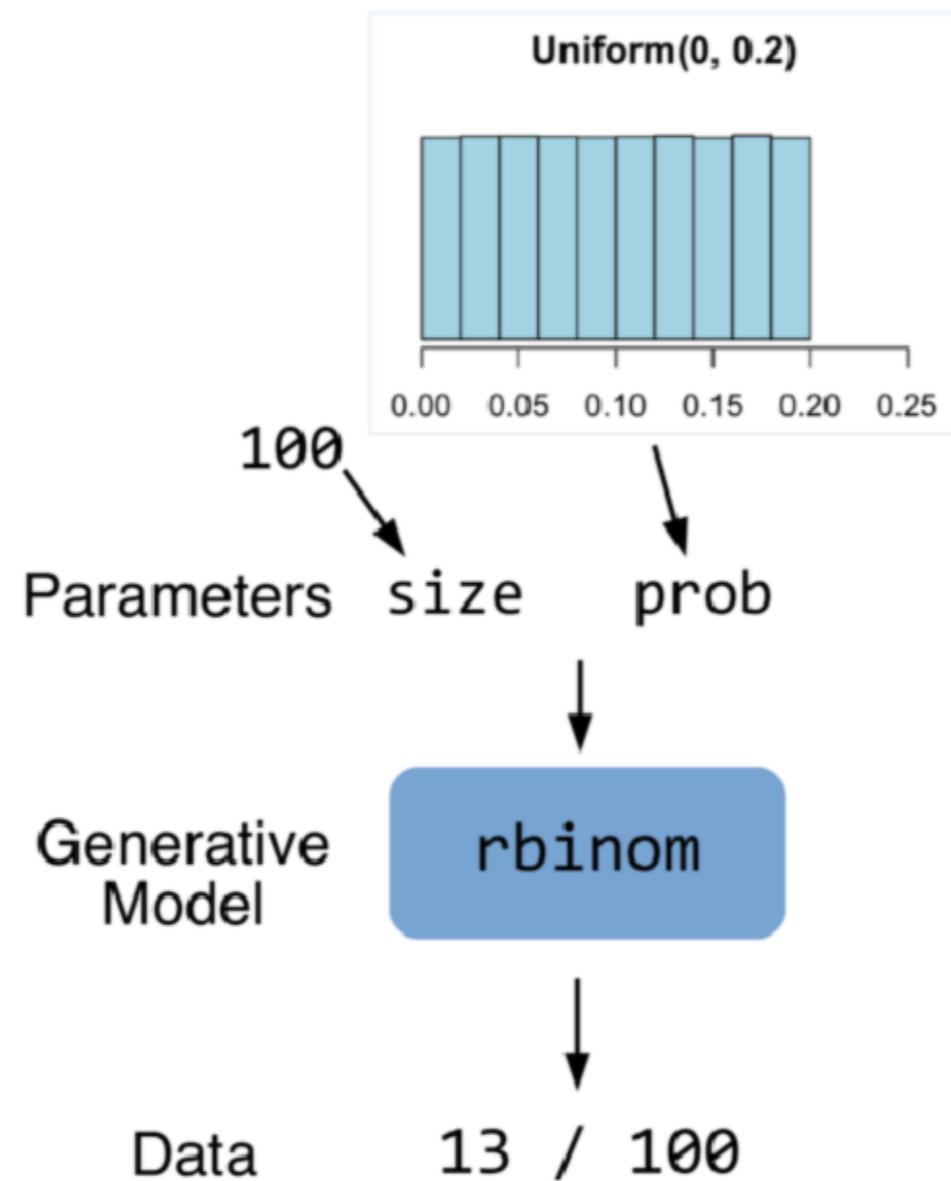
FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R

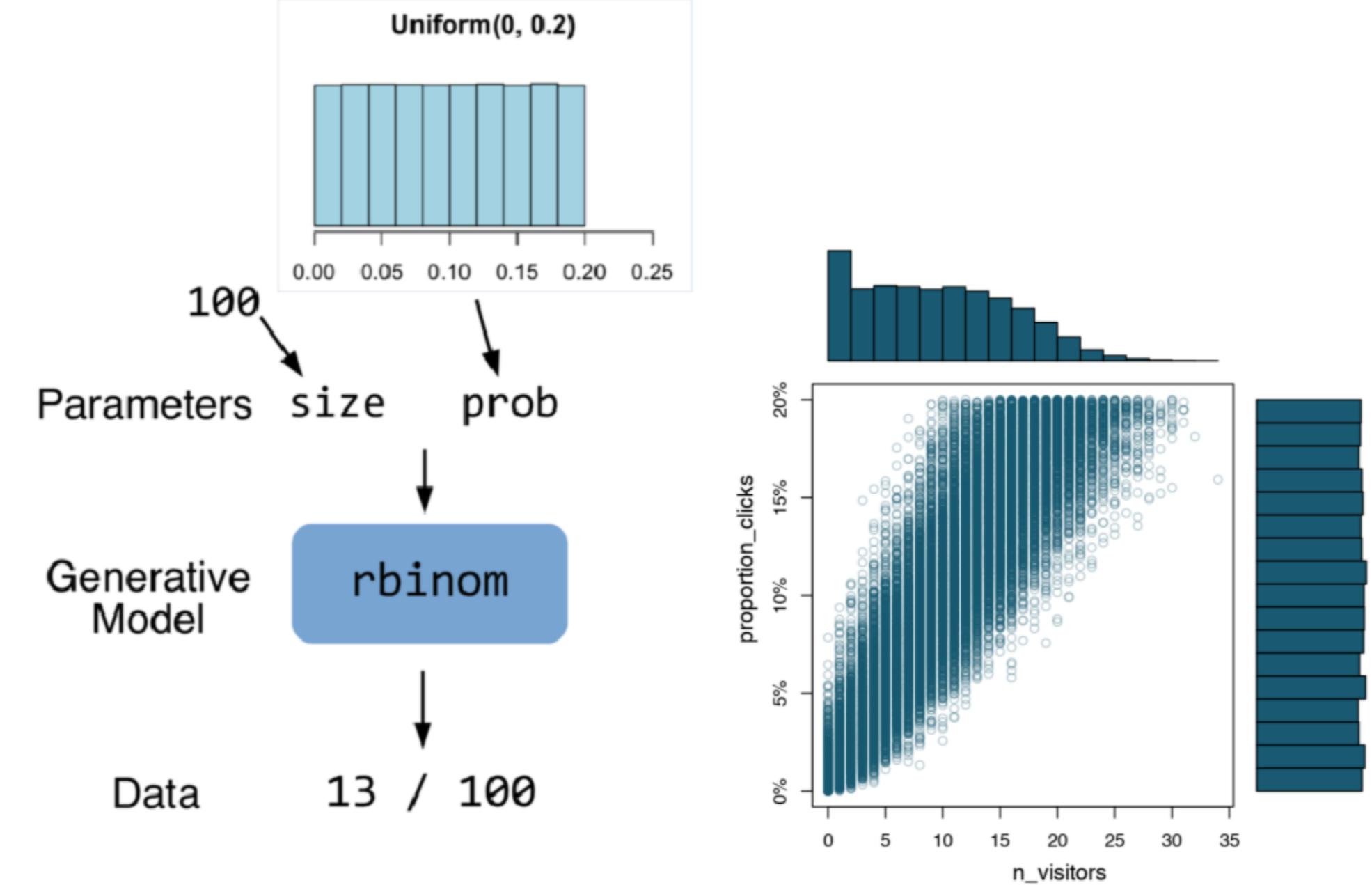


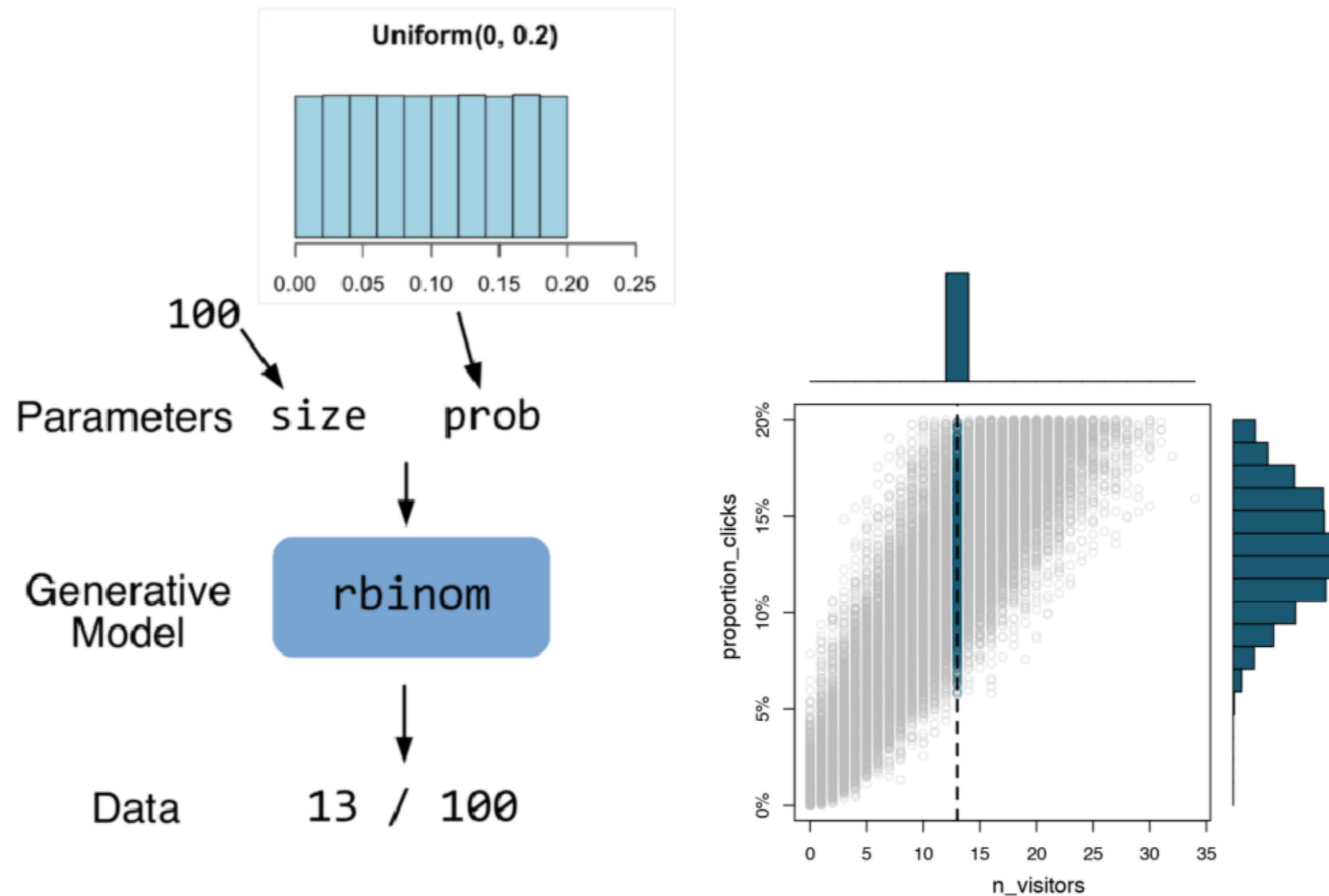
Rasmus Bååth  
Data Scientist

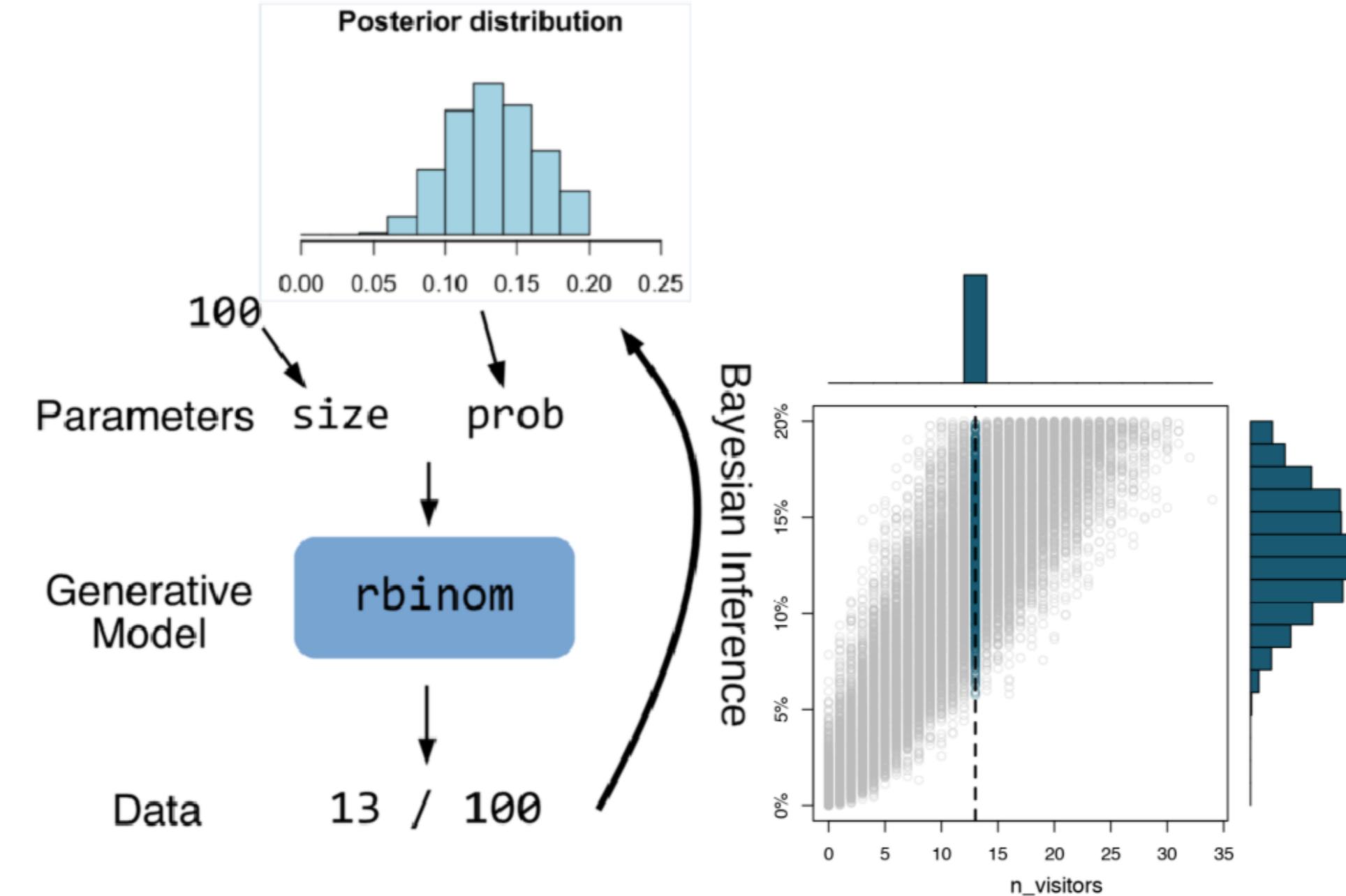
```
prop_success <- 0.1
size <- 100
# Simulating data
data <- c()
for(i in 1:size) {
  data[i] <-
    runif(1, min = 0, max = 1) <
      prop_success
}
data <- as.numeric(data)
```

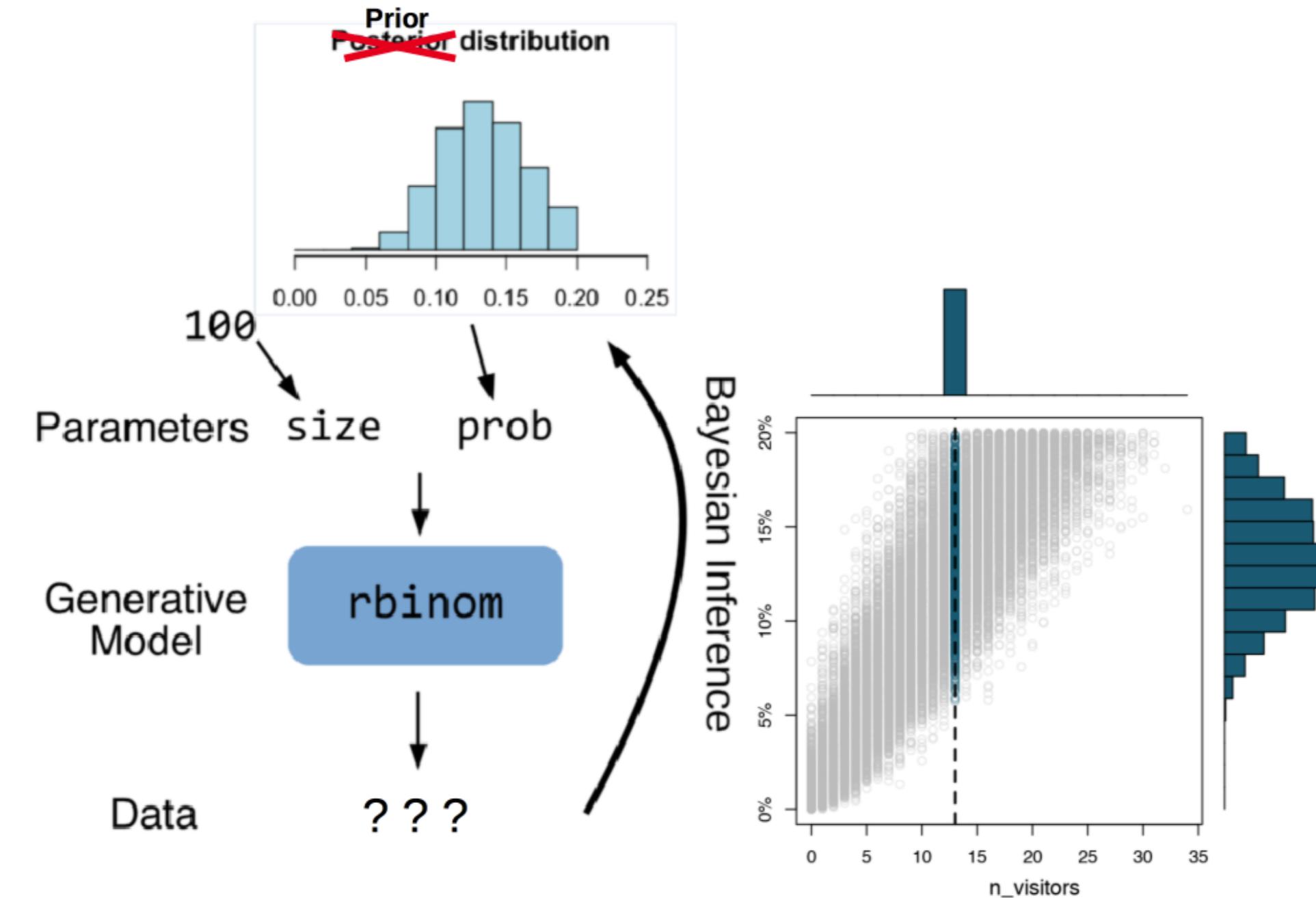




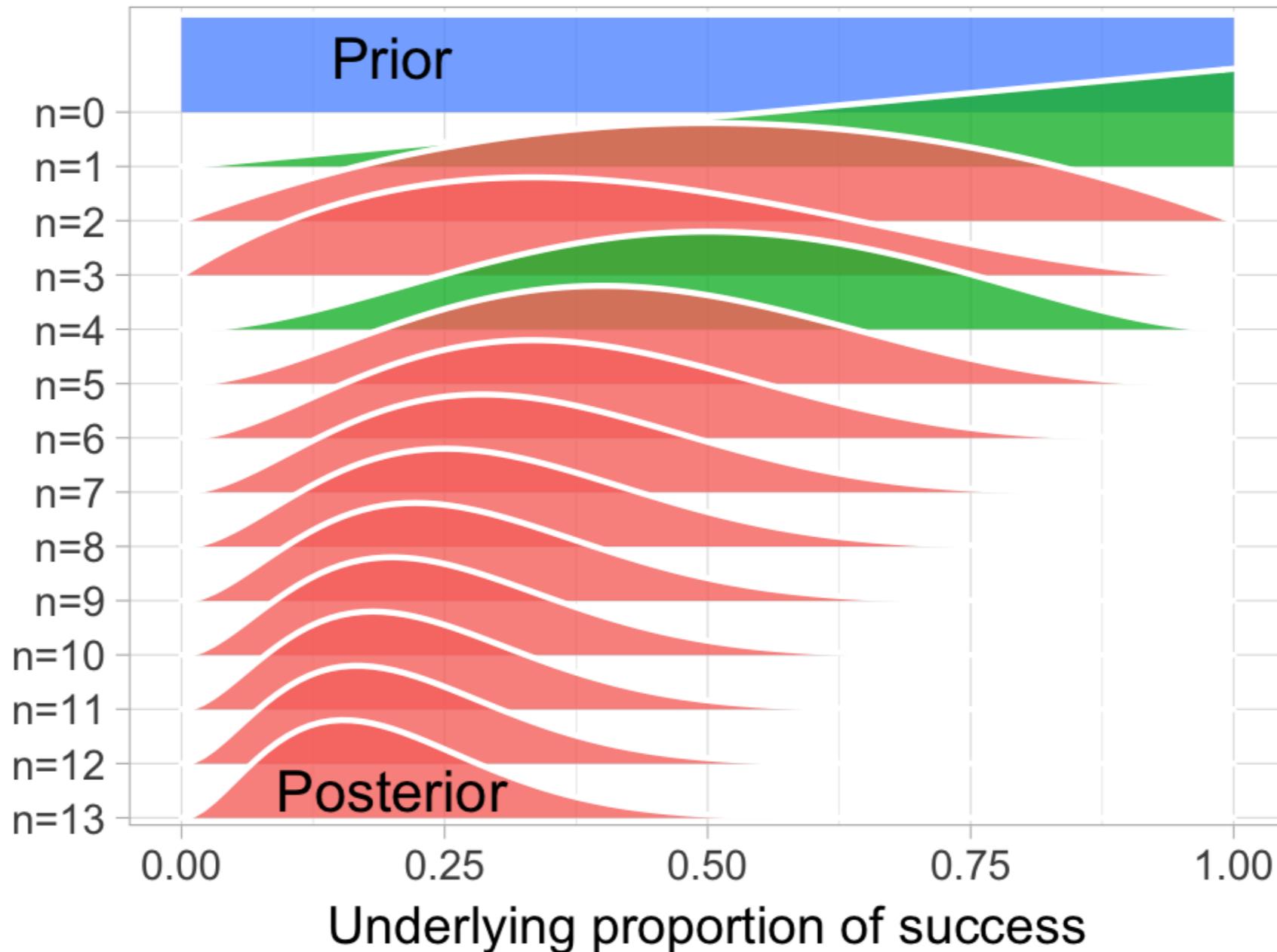


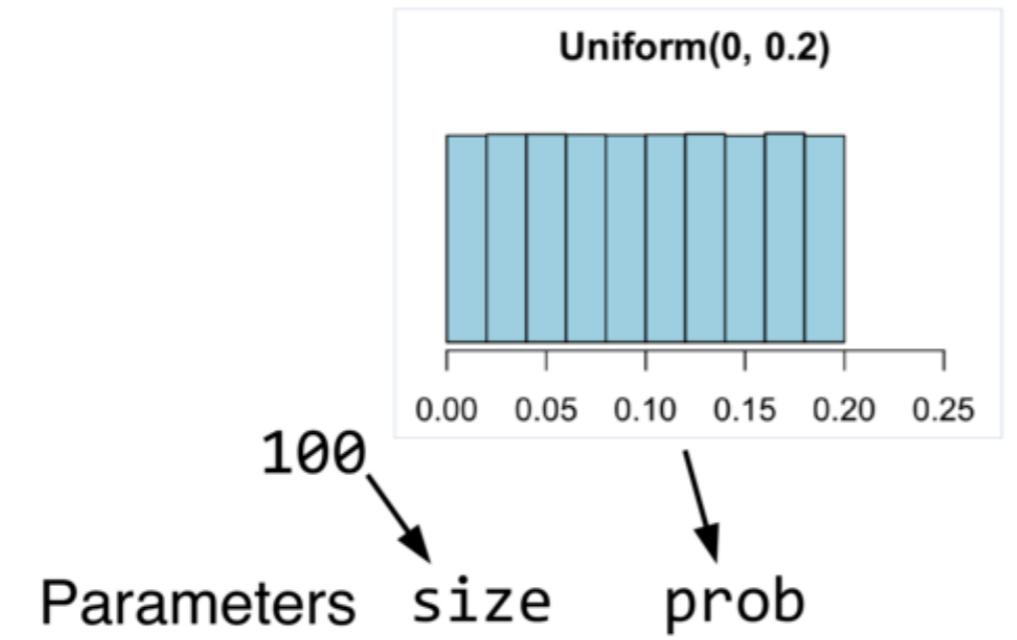


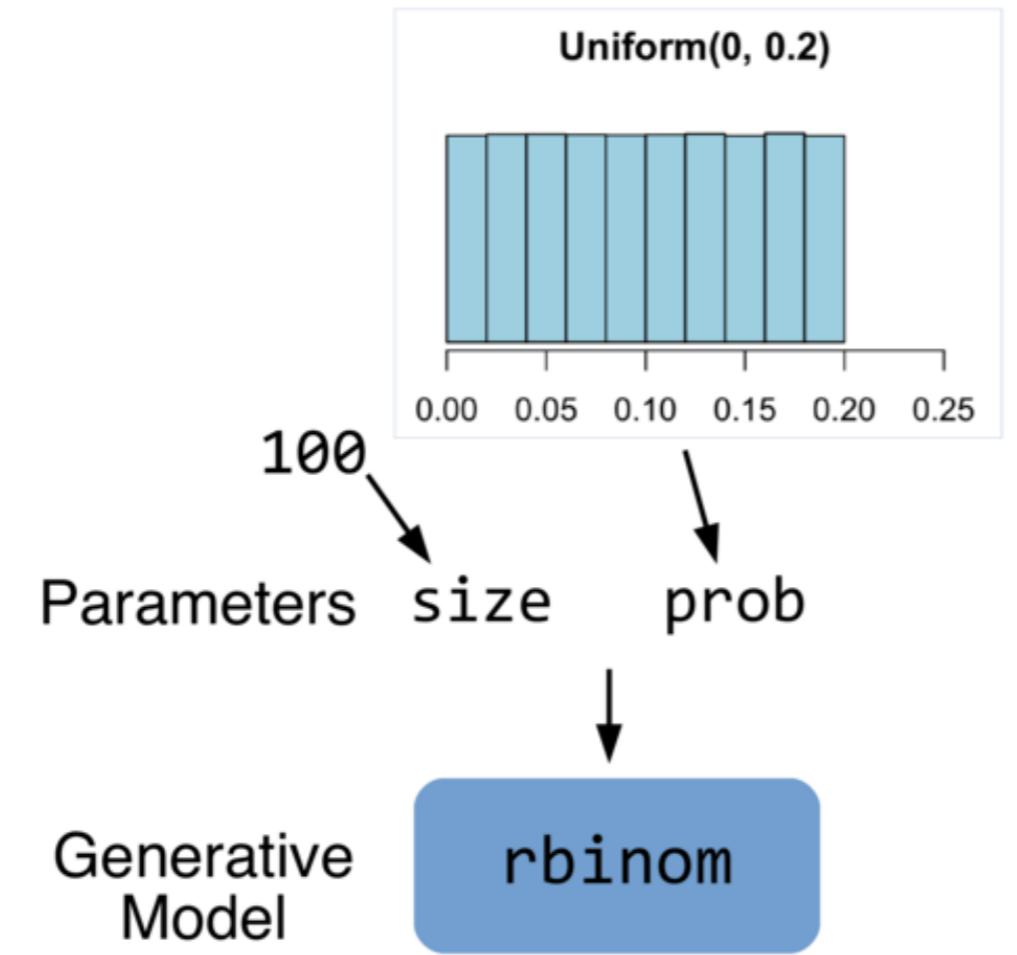


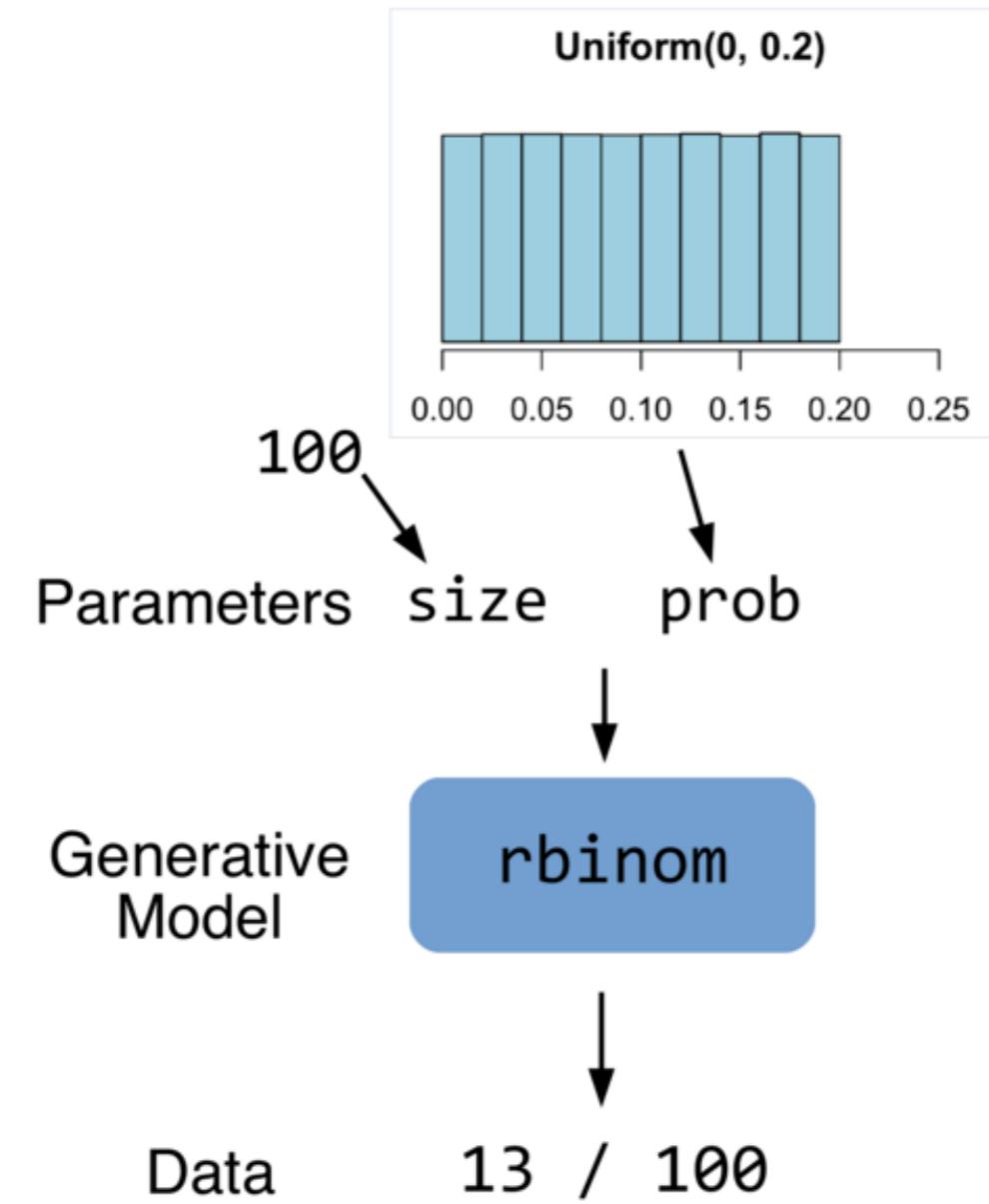


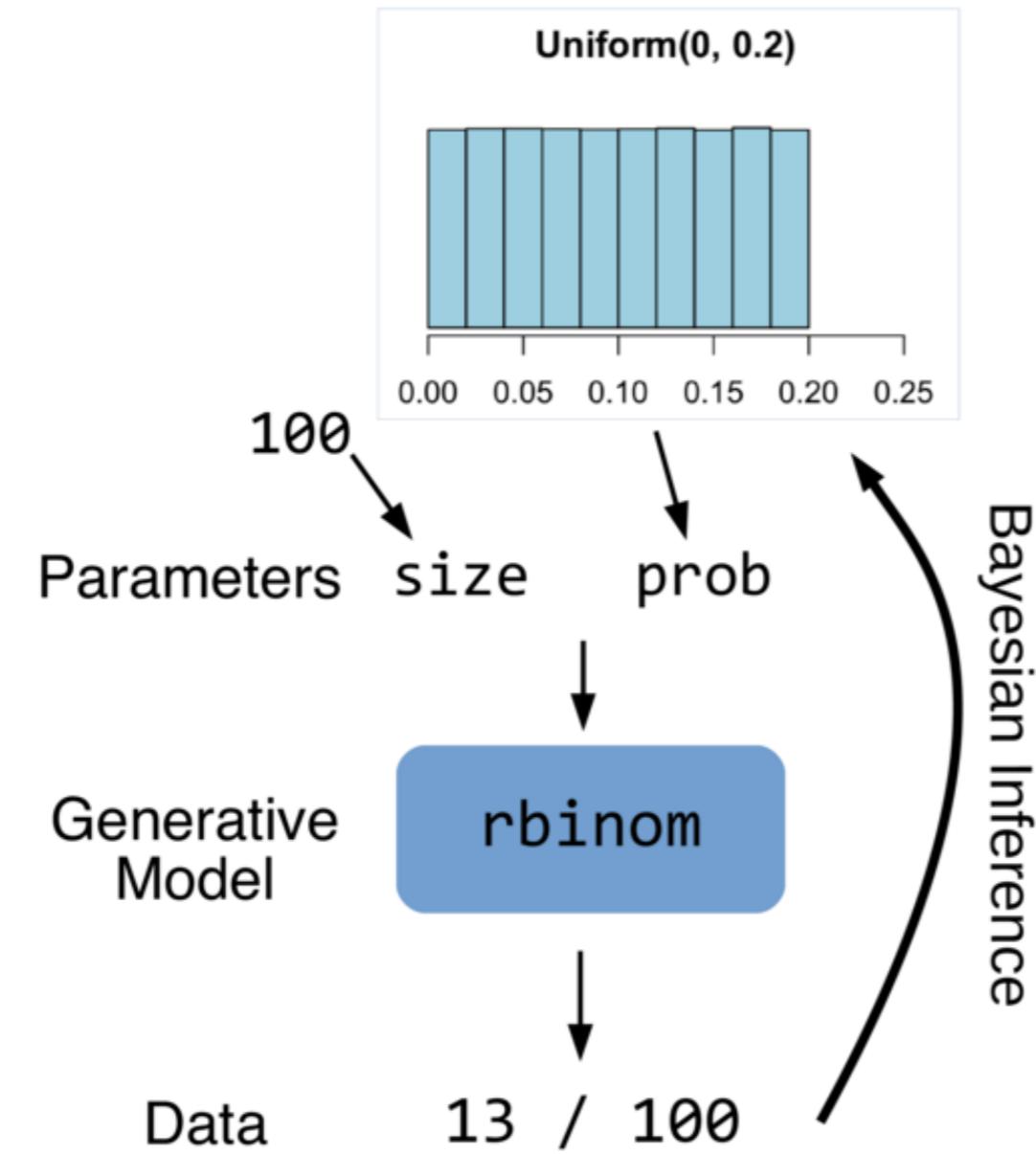
Prior Success Failure

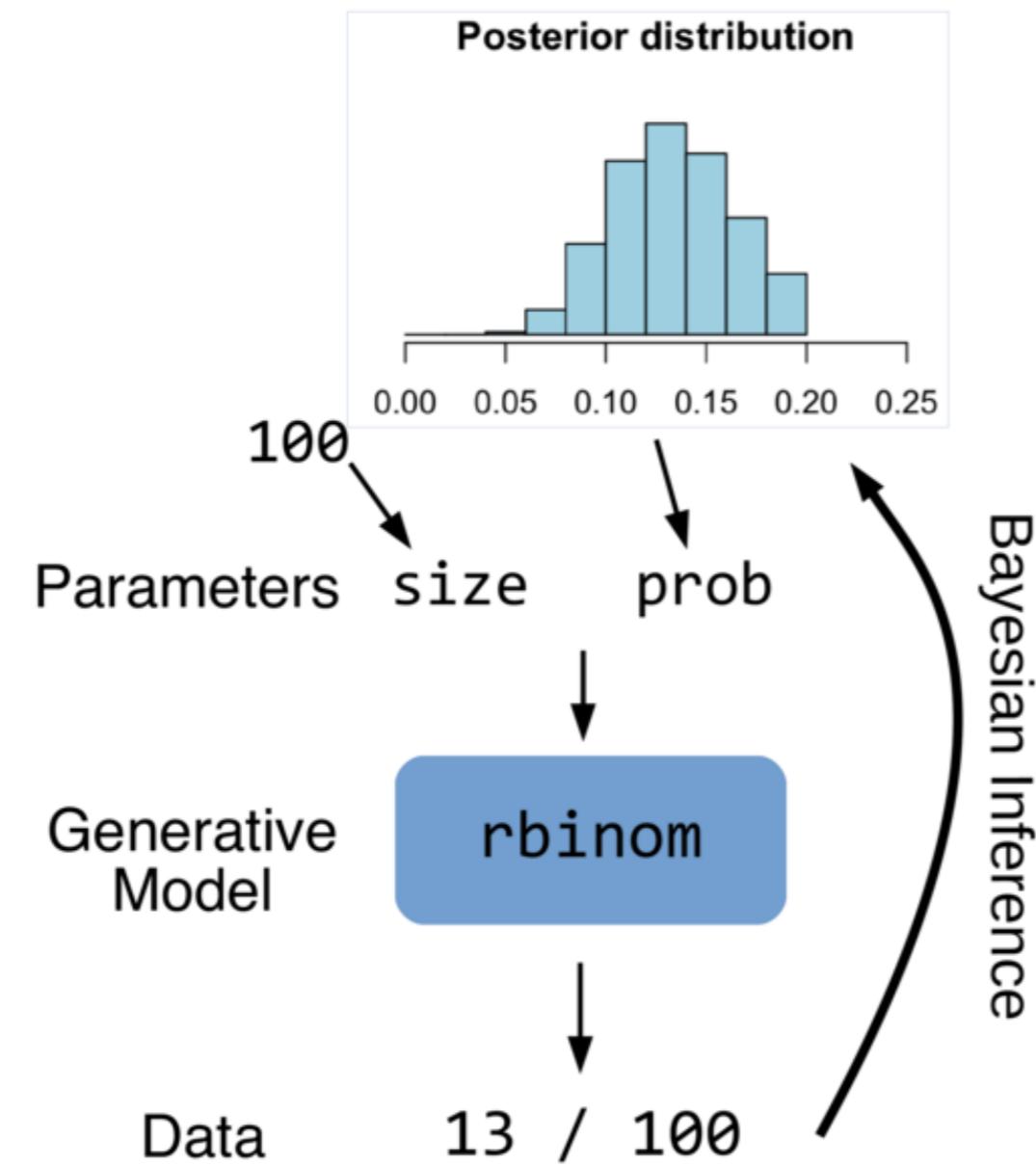


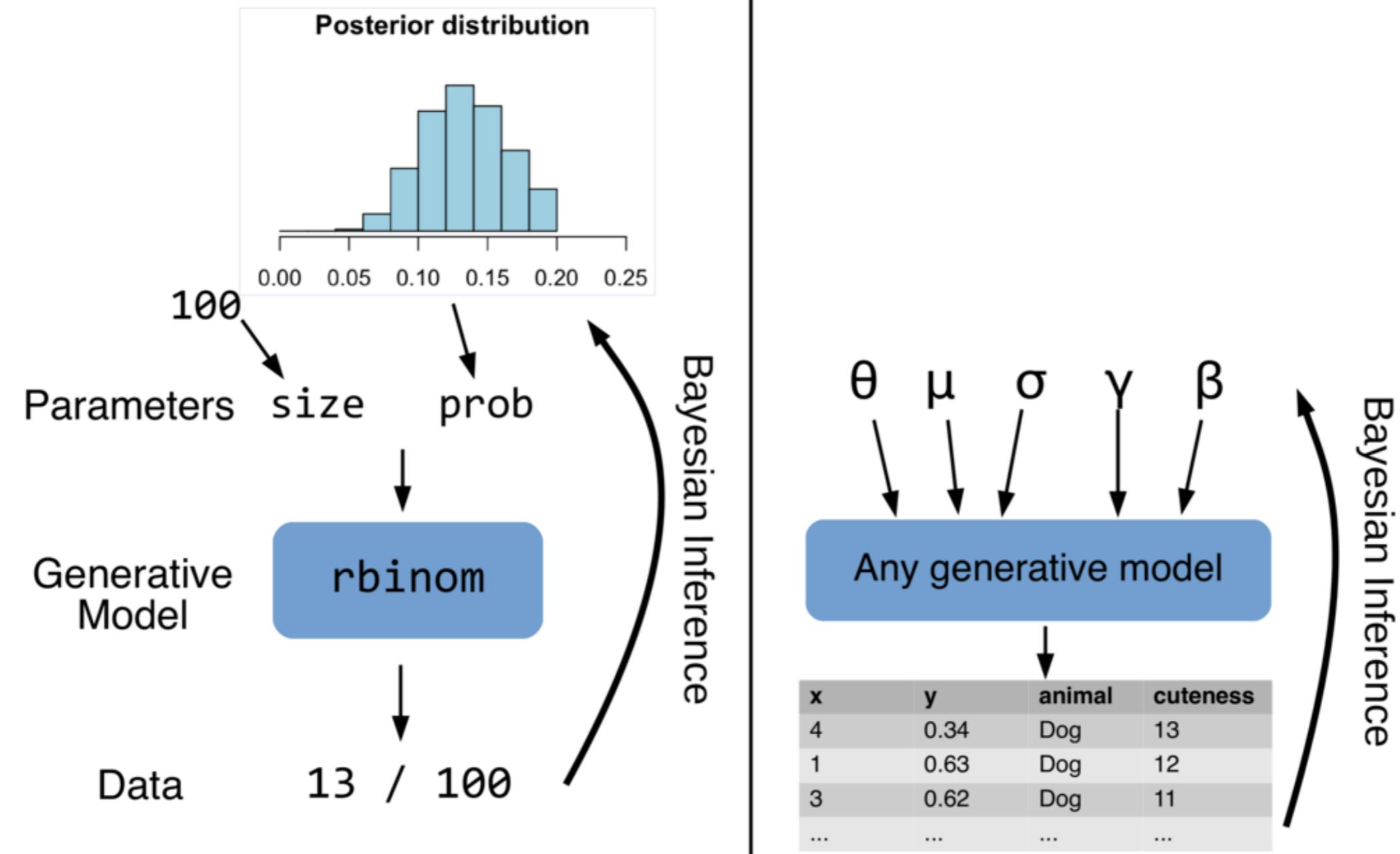


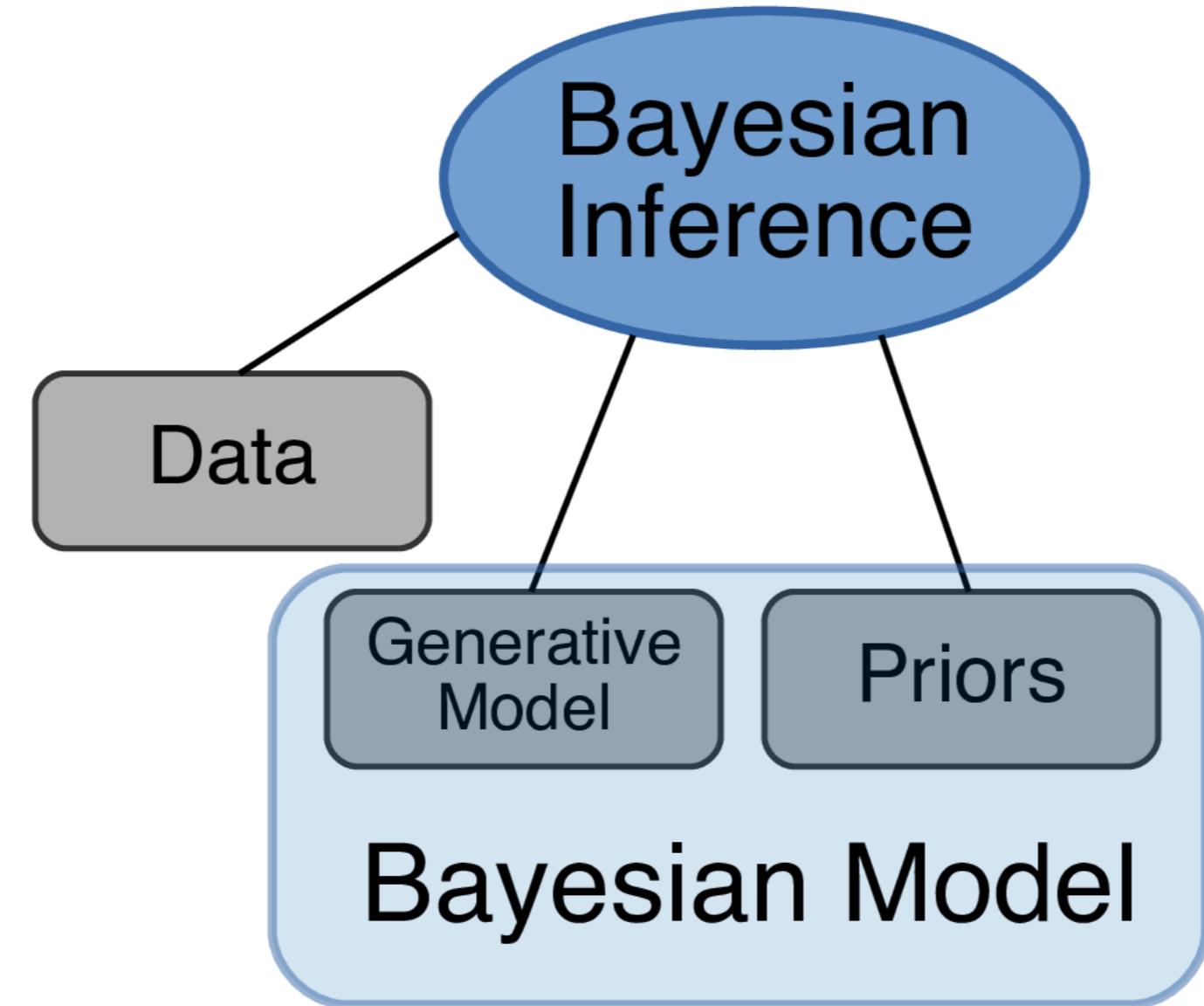


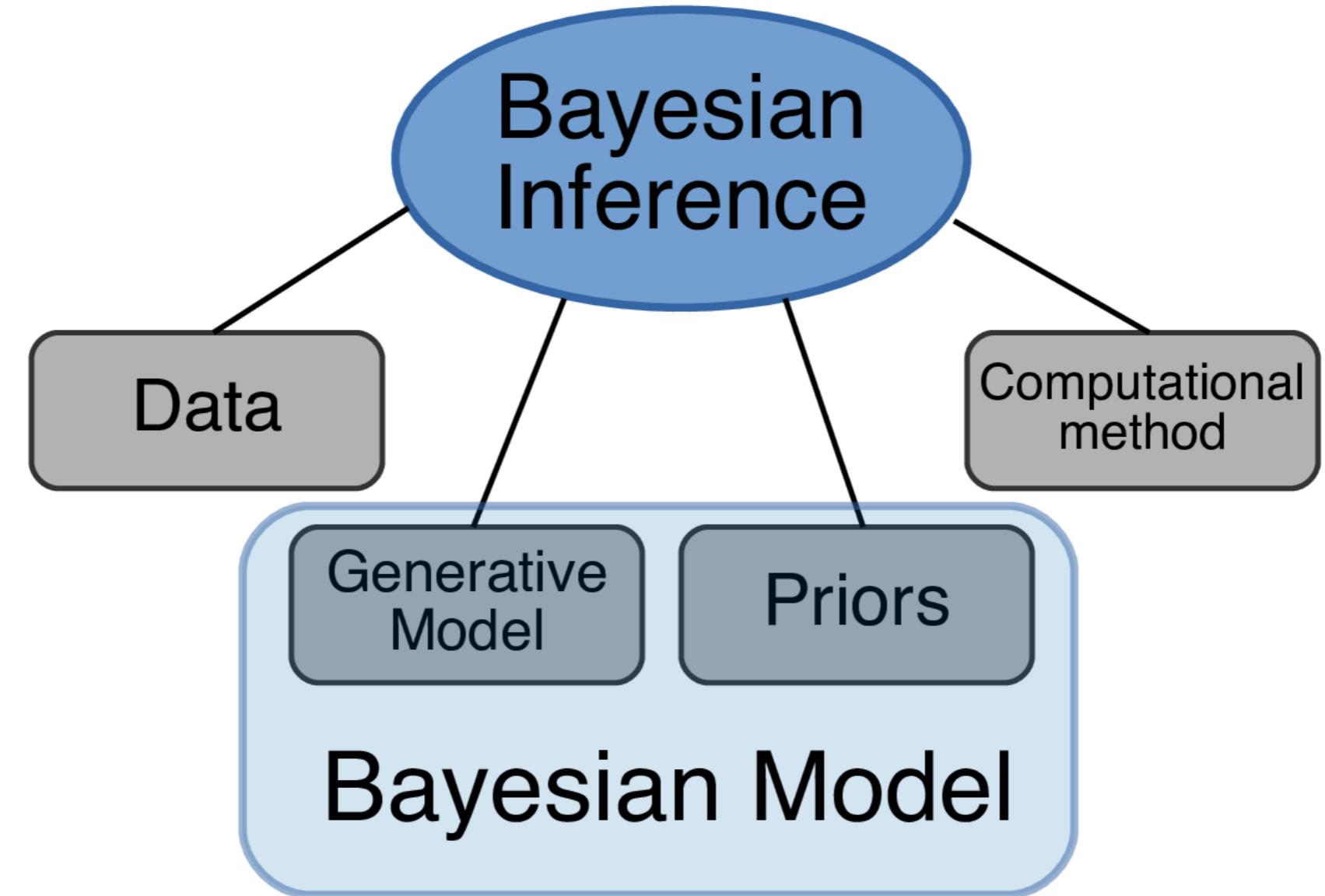












# Next up: Why use Bayes?

FUNDAMENTALS OF BAYESIAN DATA ANALYSIS IN R