BAYESIAN MODELING WITH RJAGS

The prior model

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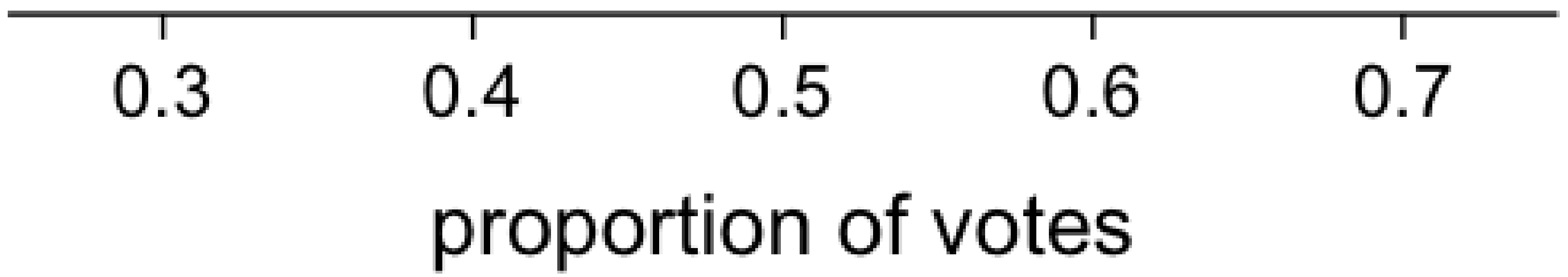
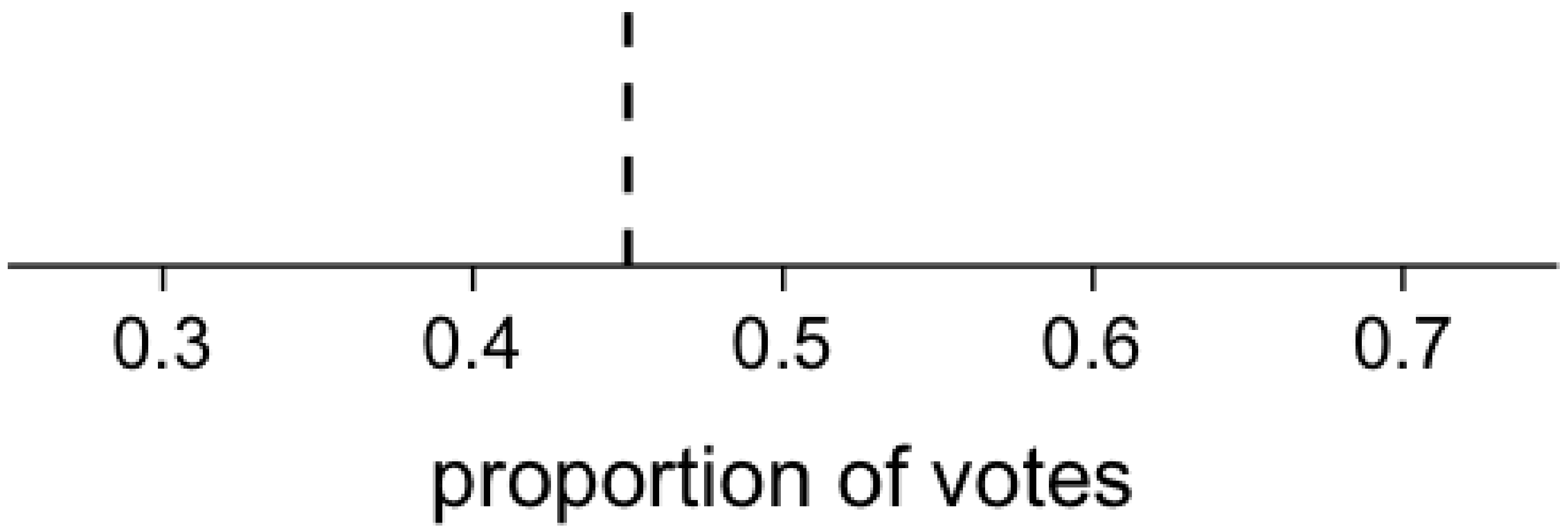
Course Goals

- Explore foundational, generalizable Bayesian models (eg: Beta-Binomial, Normal-Normal, and Bayesian regression)
- **Define**, **compile**, and **simulate** Bayesian models using RJAGS
- Conduct Bayesian posterior inference using RJAGS output

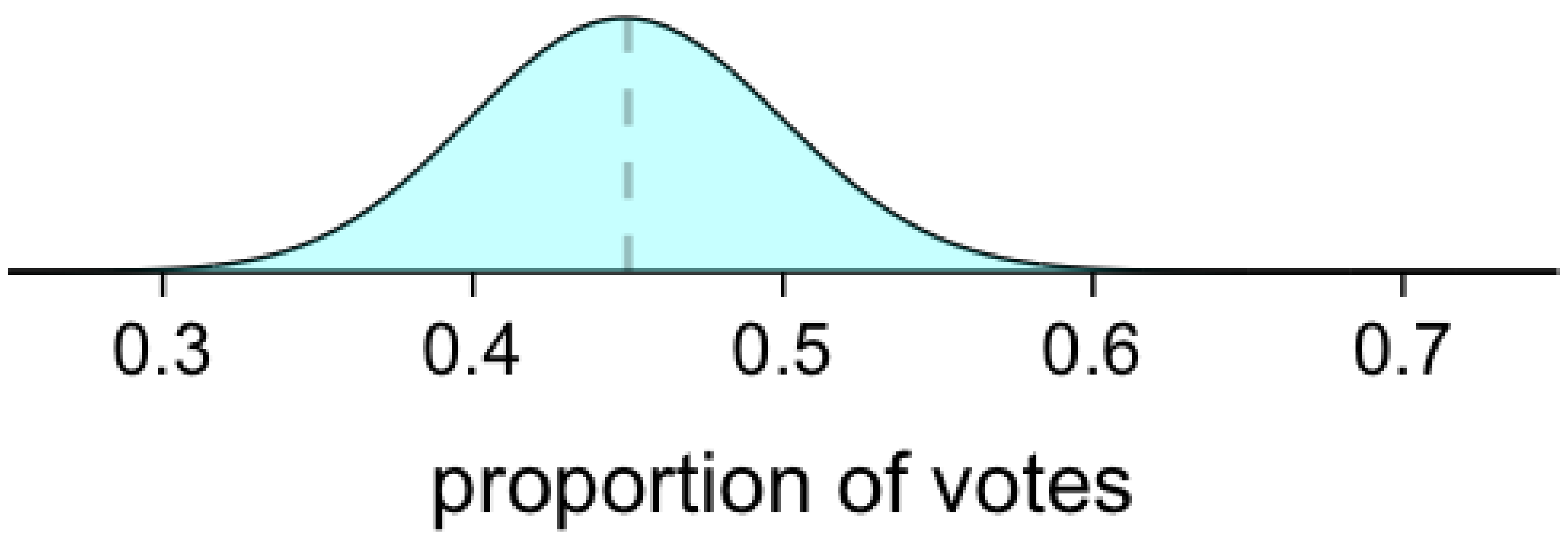
Bayesian elections: The prior



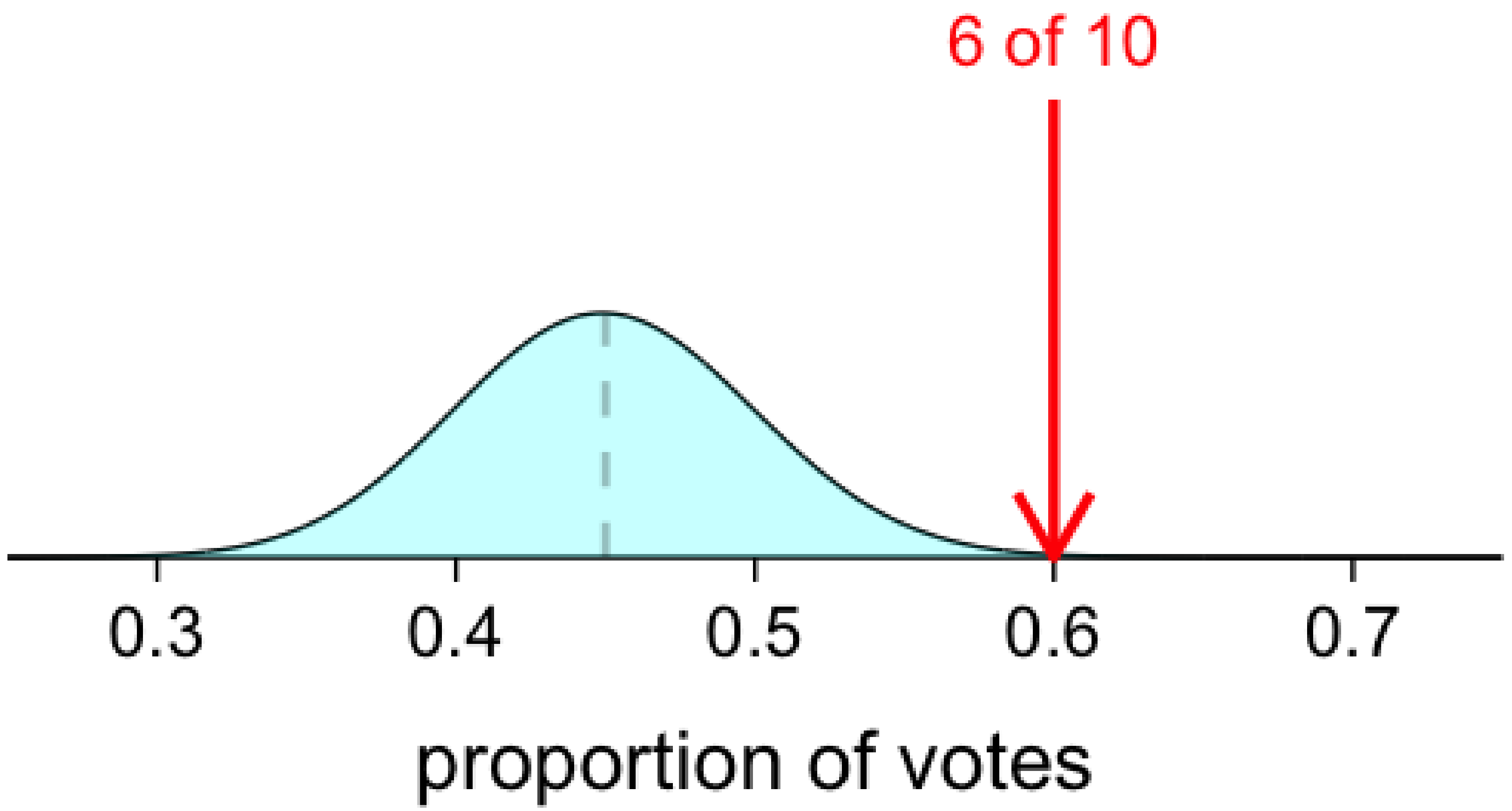
Bayesian elections: The prior



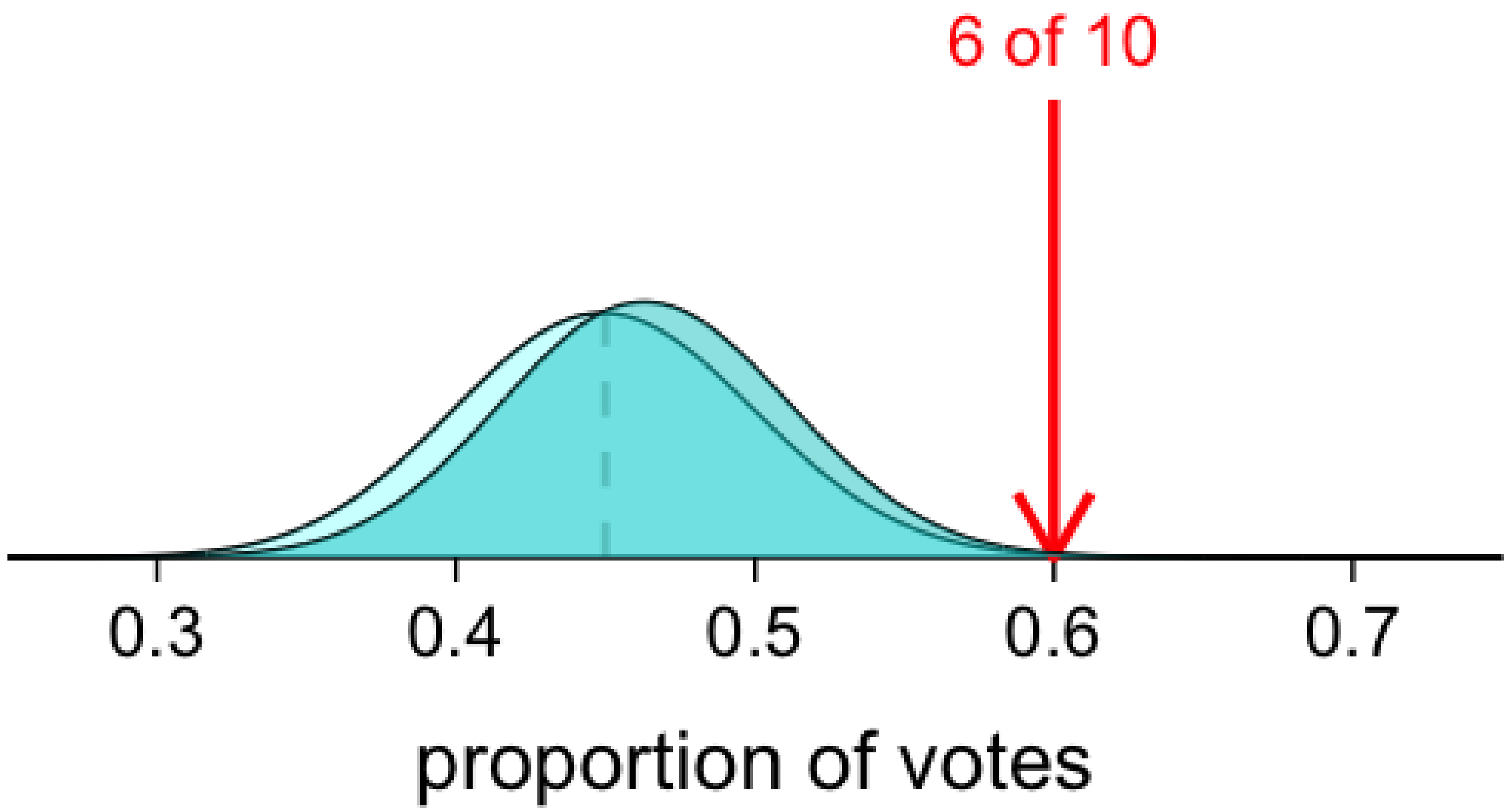
Bayesian elections: The prior



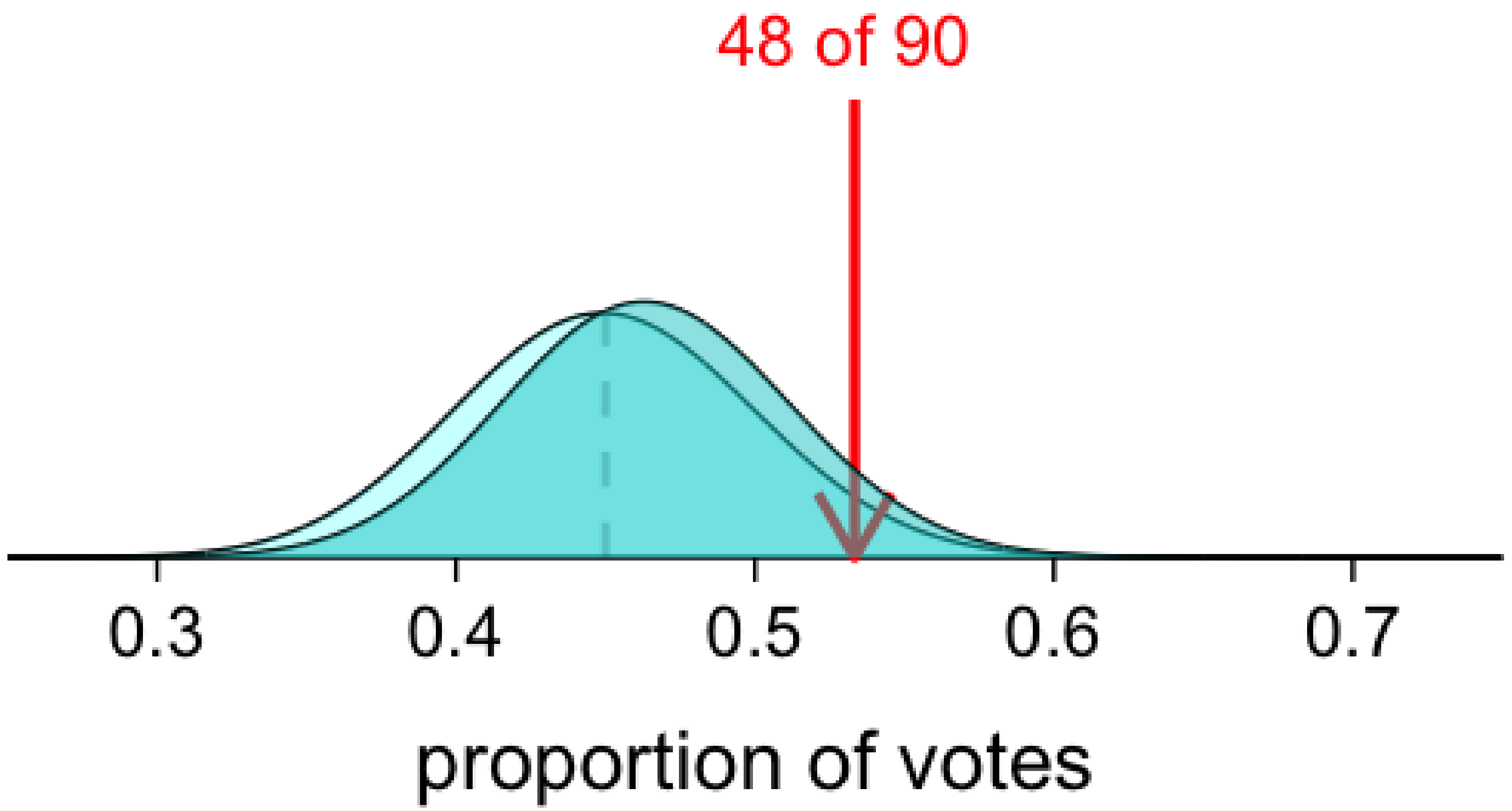
Bayesian elections: The data



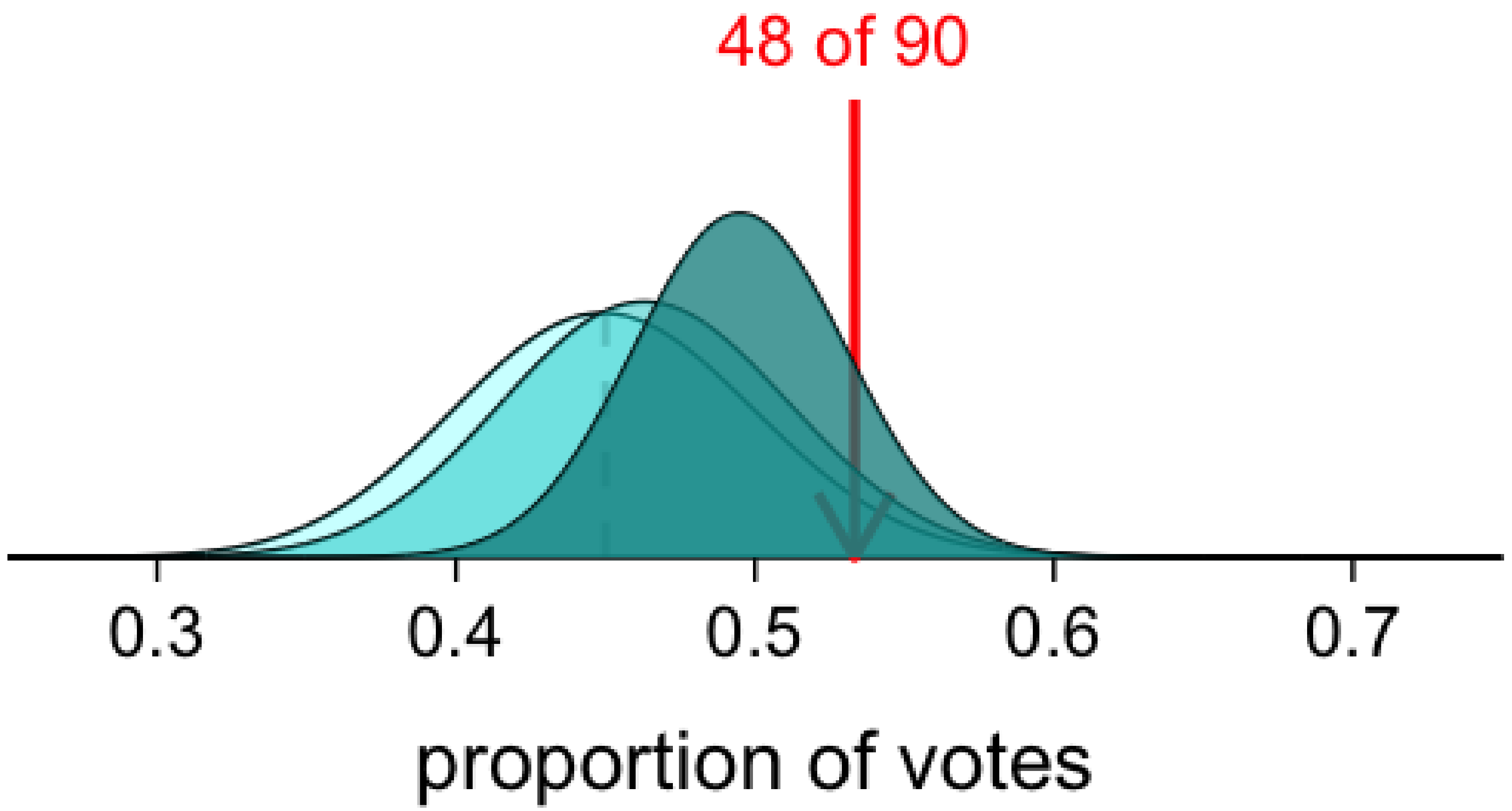
Bayesian elections: The posterior



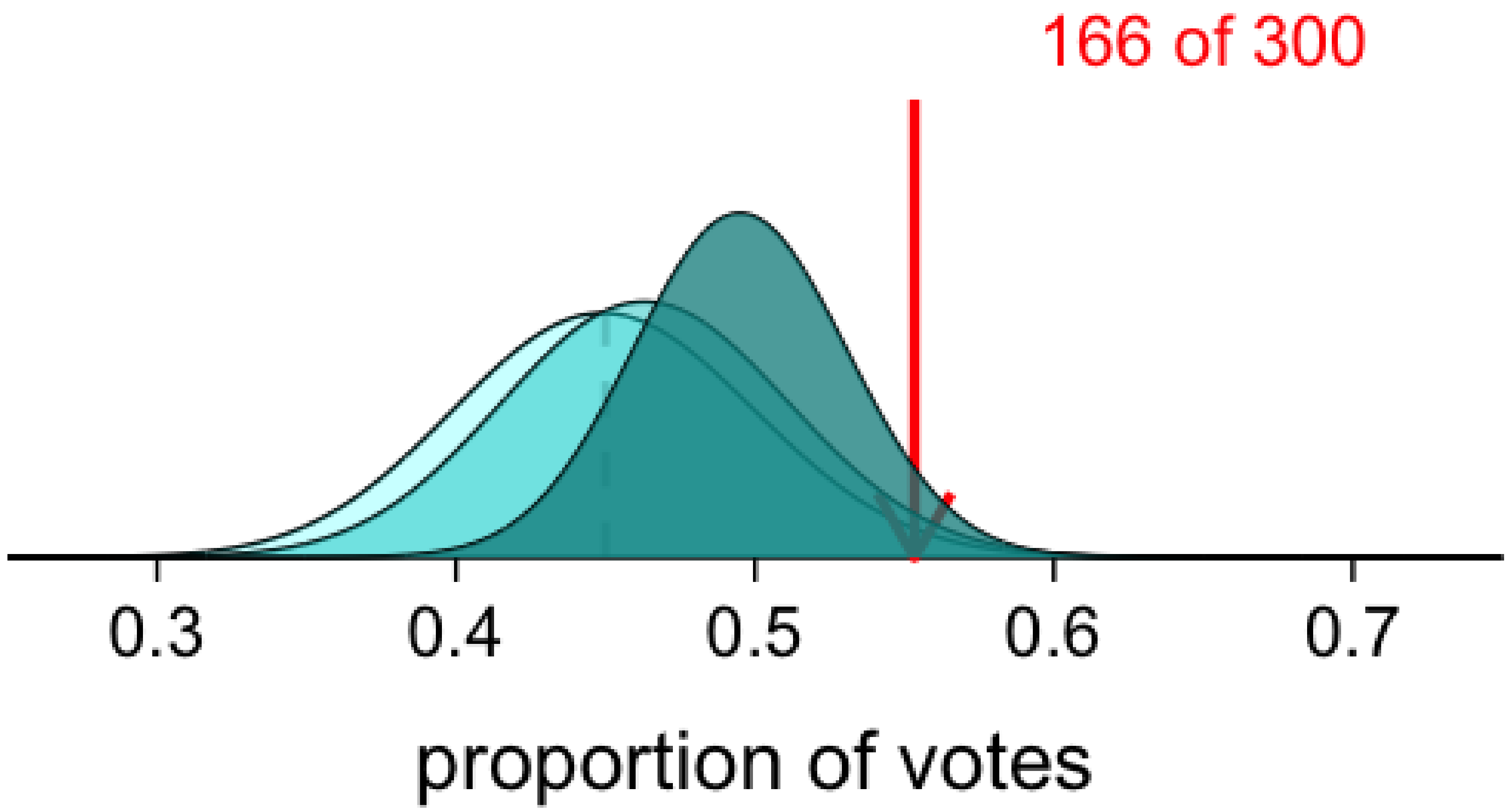
Bayesian elections: New data



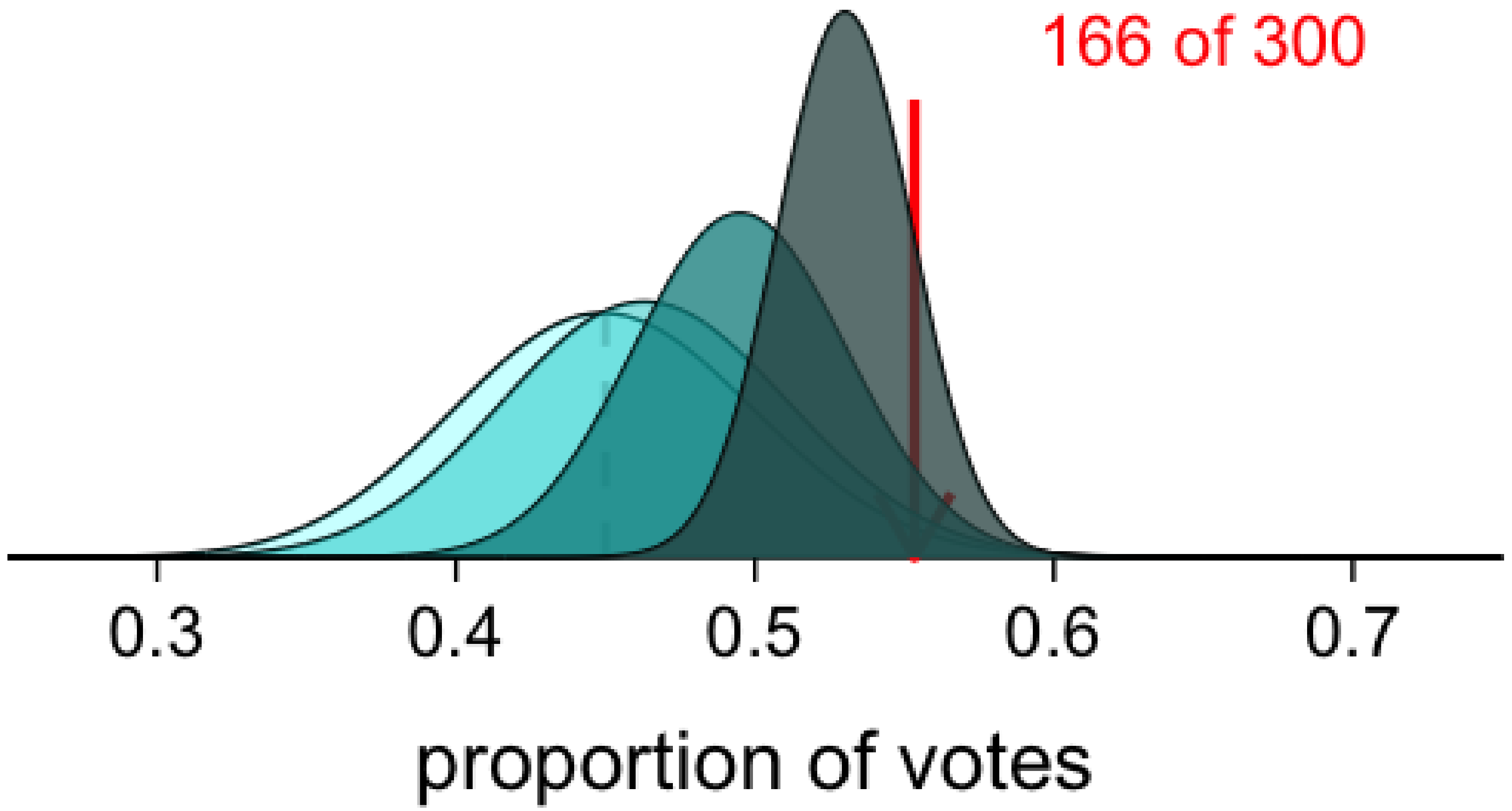
Bayesian elections: New posterior



Bayesian elections: Newer data



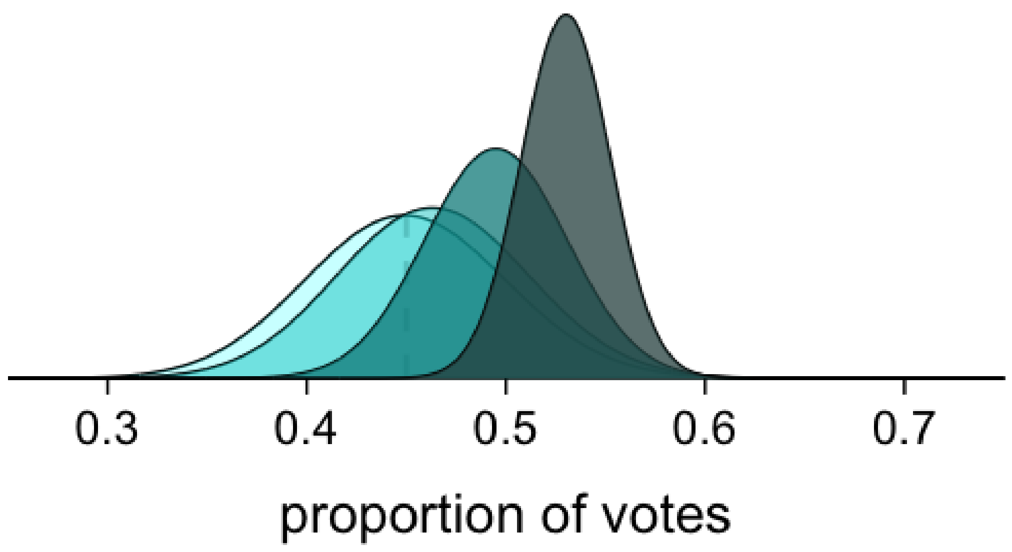
Bayesian elections: Newer posterior



Bayesian thinking

A Bayesian posterior model...

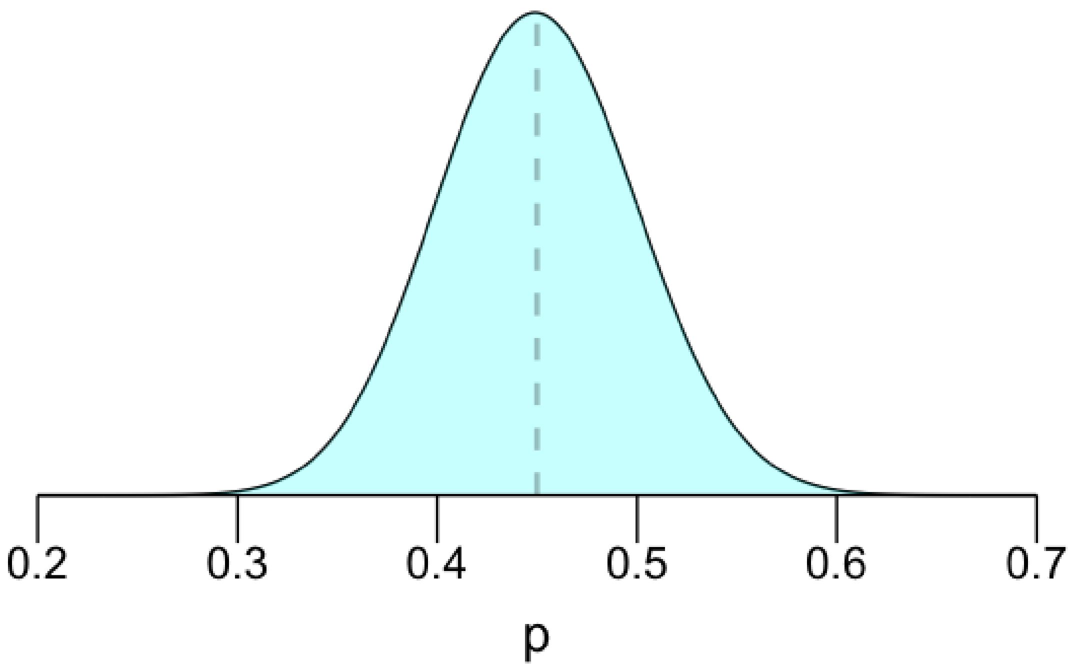
- combines insights from the prior model & observed data
- evolves as new data come in



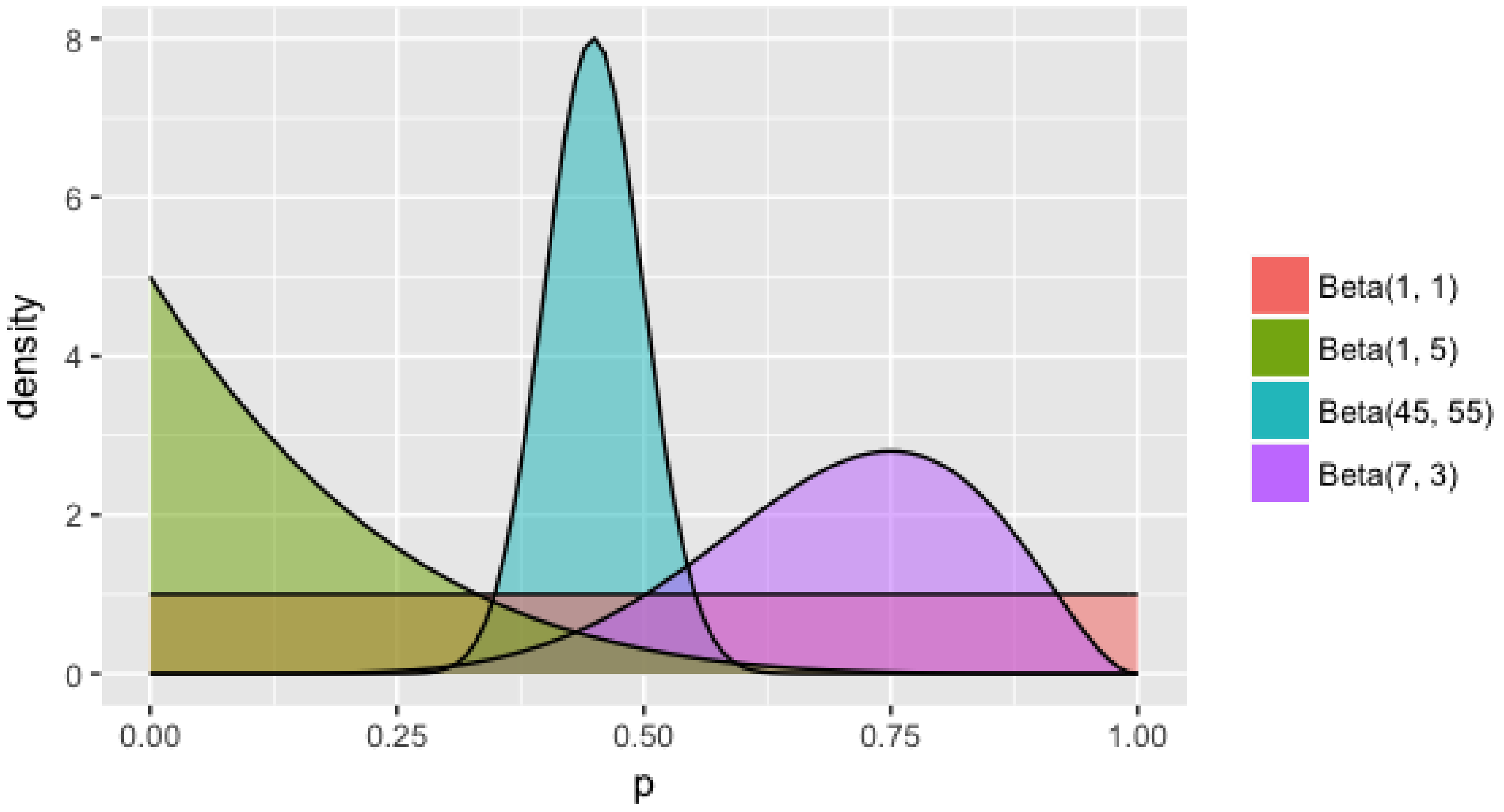
Building a prior model

- p = proportion that support you
- p is between 0 and 1
- The prior model for p is a **Beta distribution** with **shape parameters** 45 and 55

$$p \sim Beta(45, 55)$$



Tuning the prior



BAYESIAN MODELING WITH RJAGS

Let's practice!

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Data & the likelihood

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Polling Data

- **parameter**

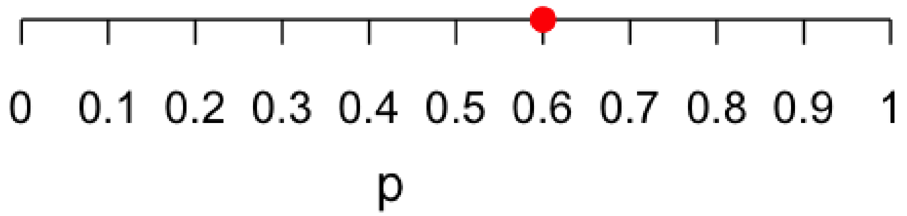
  p = proportion that support you

- **data**

  $X = 6$ of $n = 10$ polled voters plan to vote for you

- **insights**

  You are more likely to have observed these data if $p \approx 0.6$ than if $p < 0.5$.



Modeling the dependence of X on p

- **Poll assumptions:**

  voters are independent
  p = probability that a voter supports you

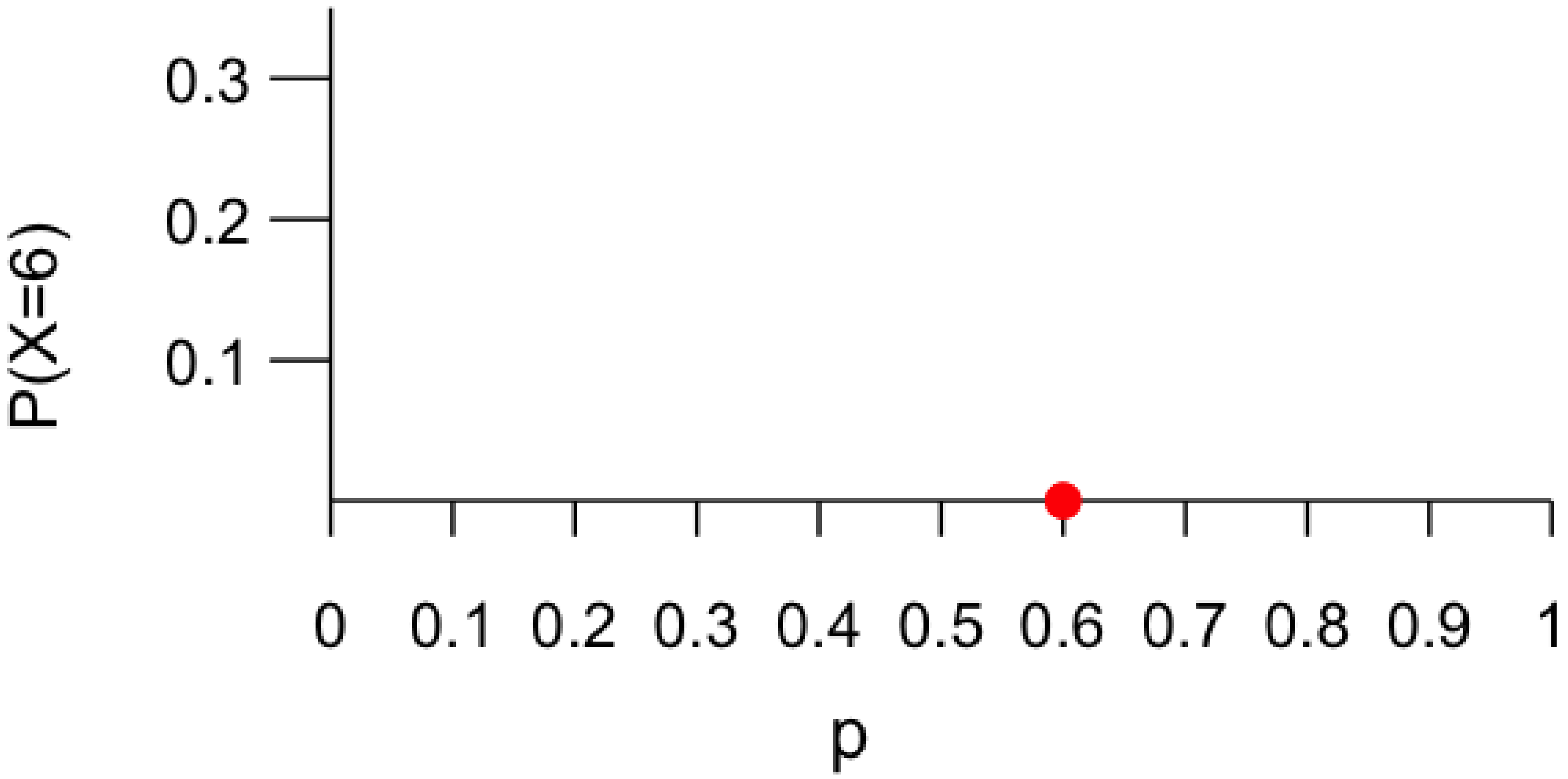
- X = number of n polled voters that support you

  (count of successes in n independent trials, each having probability of success p)

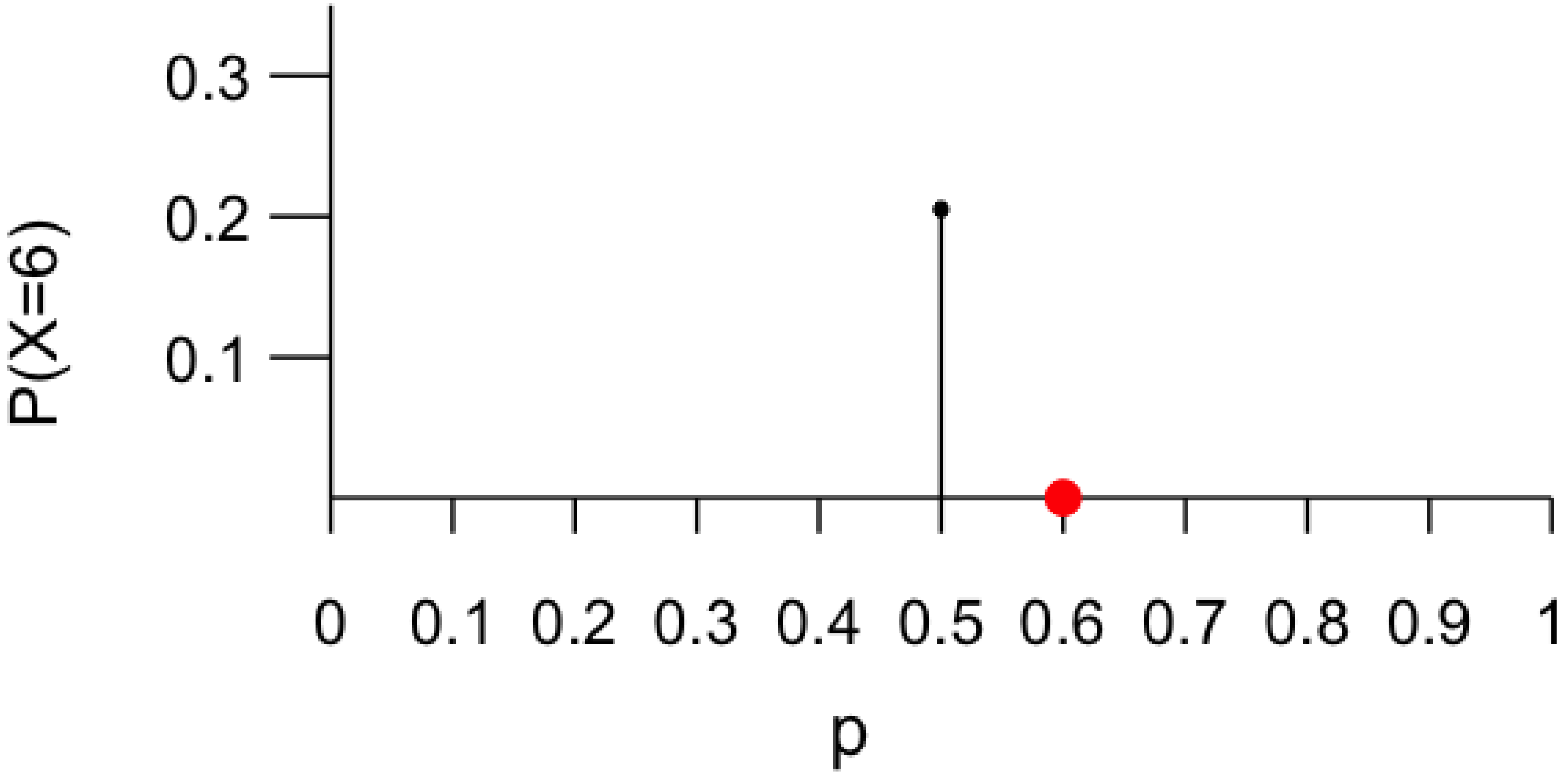
- **Conditional distribution of X given p:**

  $X \sim Bin(n, p)$

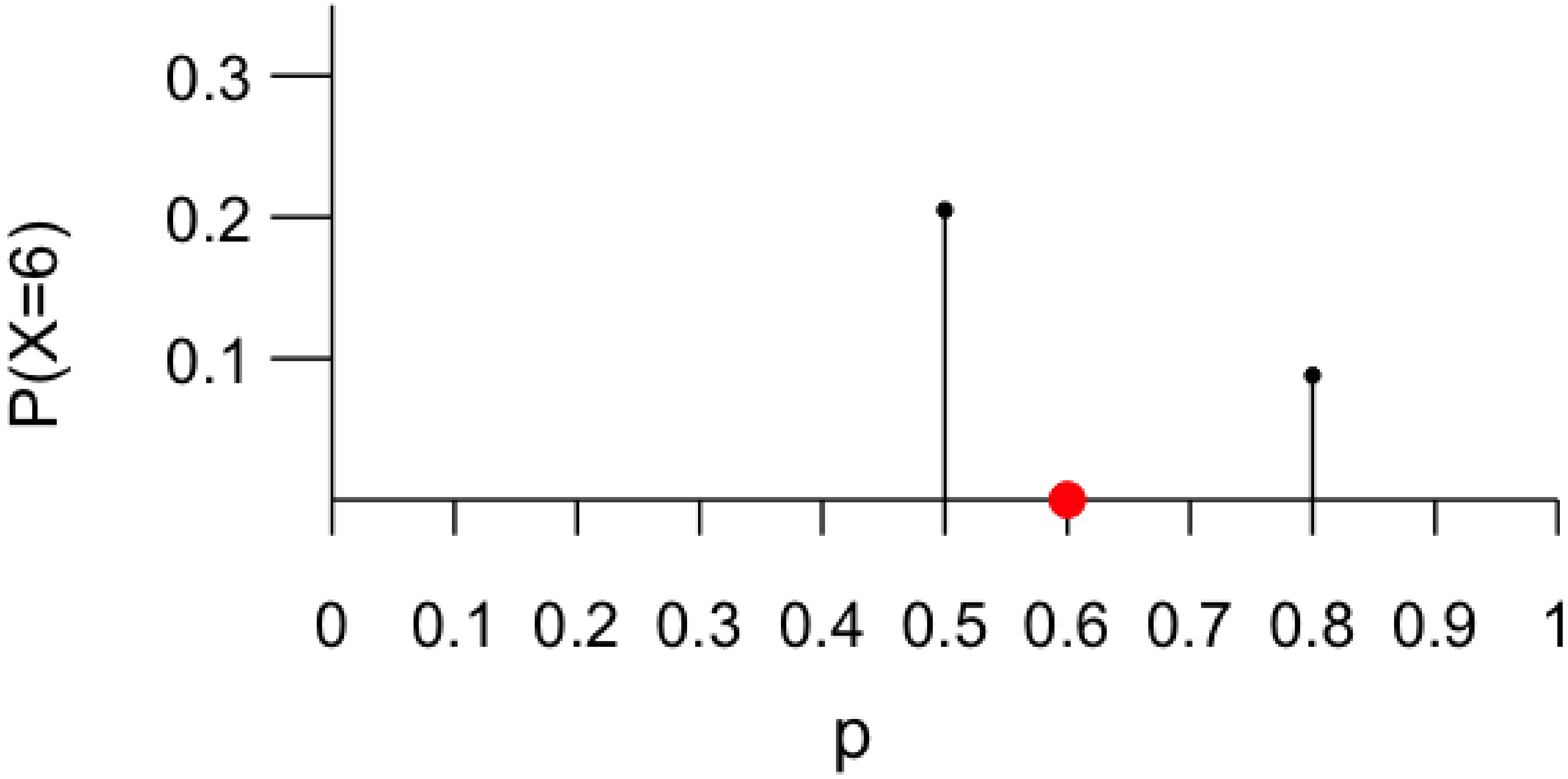
Dependence of X on p



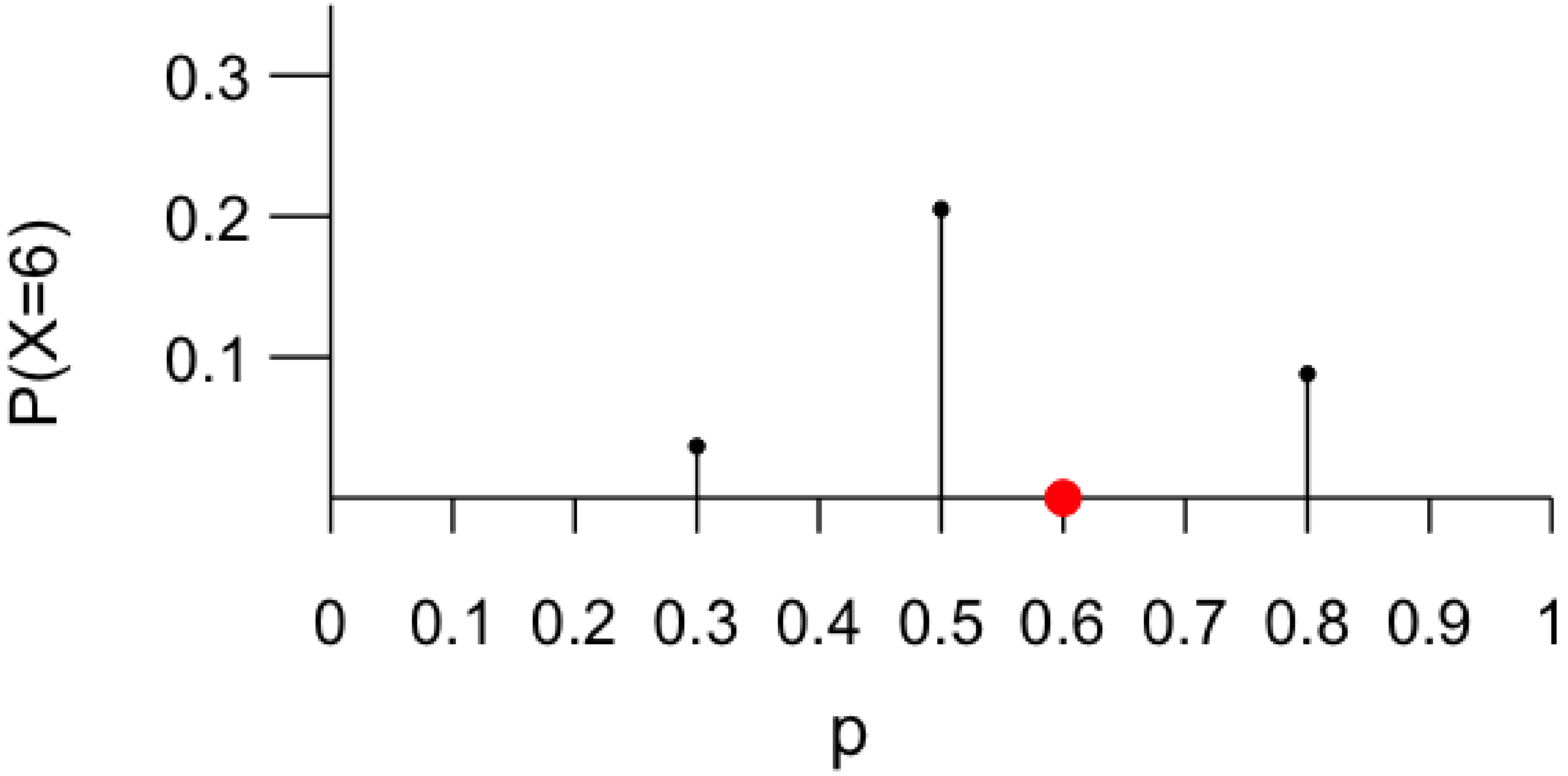
Dependence of X on p



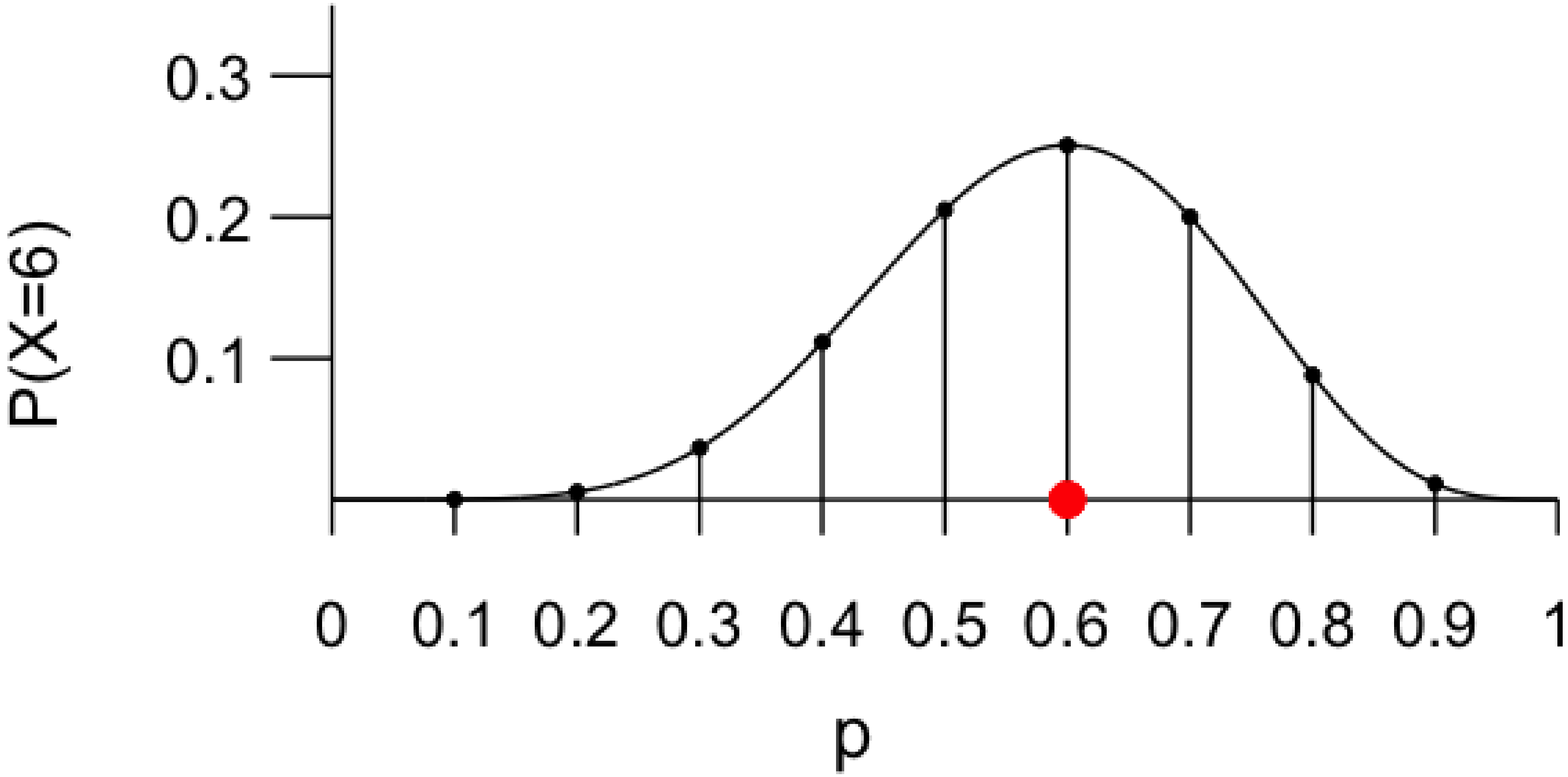
Dependence of X on p



Dependence of X on p



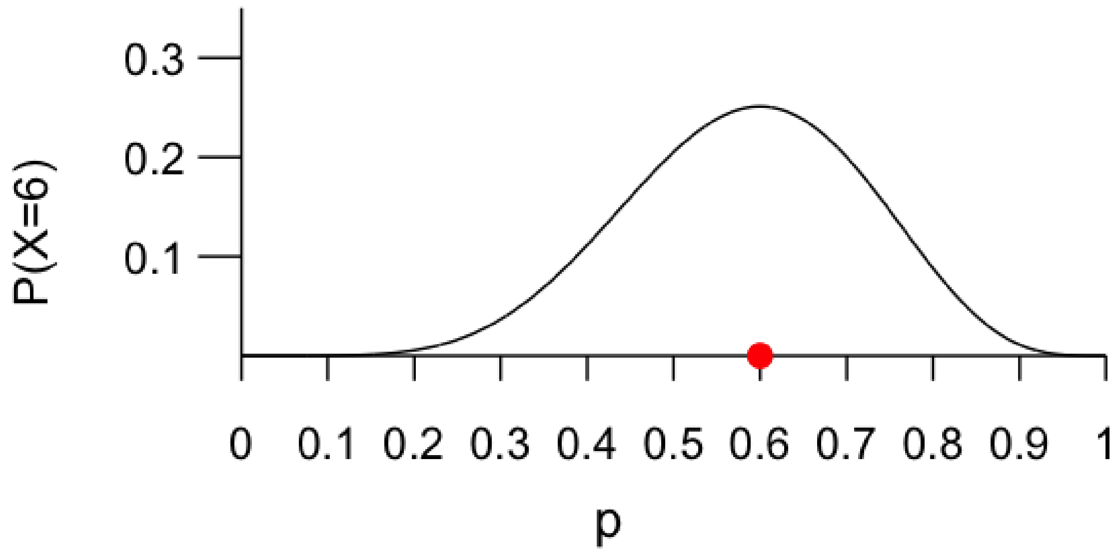
What's the likelihood?



Likelihood

The **likelihood function** summarizes the likelihood of observing polling data X under different values of the underlying support parameter p. It is a function of p.

- high likelihood $\Rightarrow$ p is compatible with the data
- low likelihood $\Rightarrow$ p is not compatible with the data



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The posterior model

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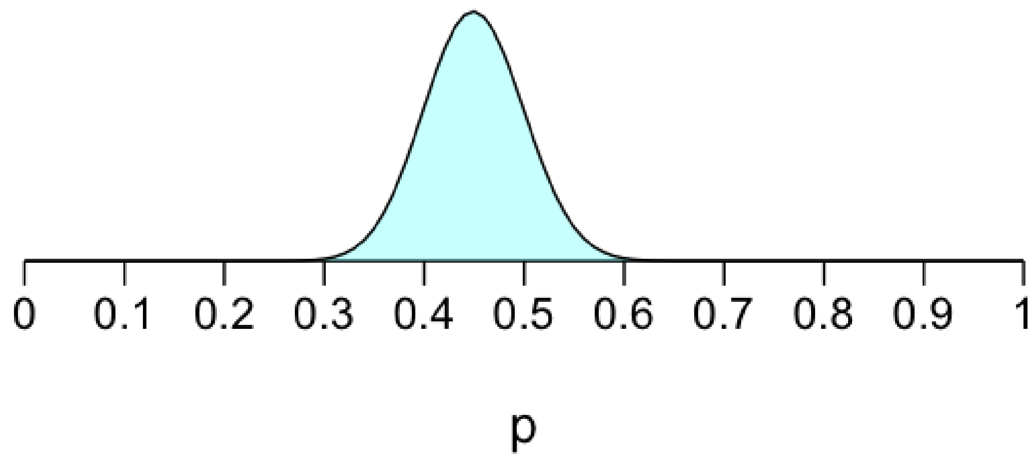
Bayesian election model

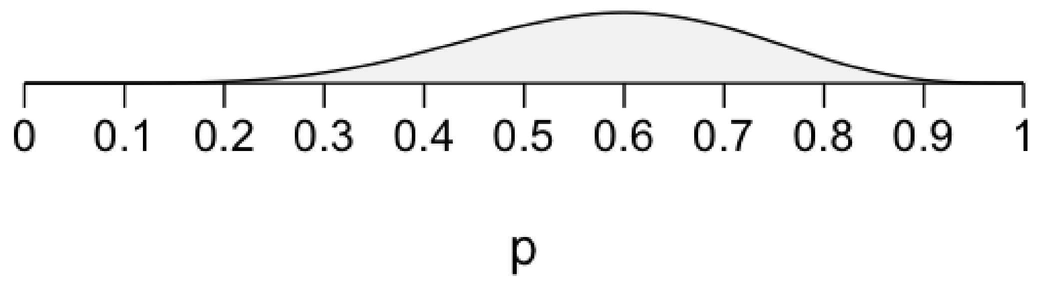
prior: $p \sim Beta(45, 55)$



Bayesian election model

prior: $p \sim Beta(45, 55)$

likelihood: $X \sim Bin(10, p)$



Bayesian election model

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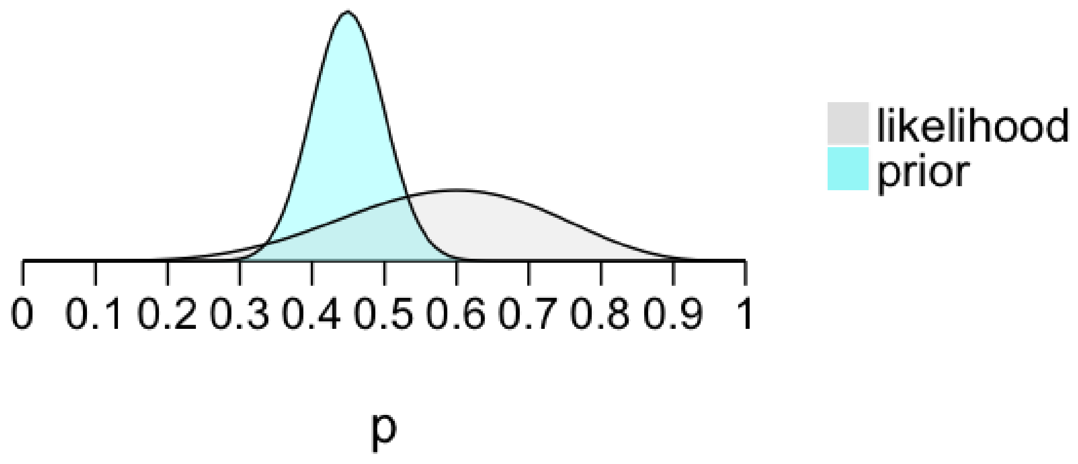
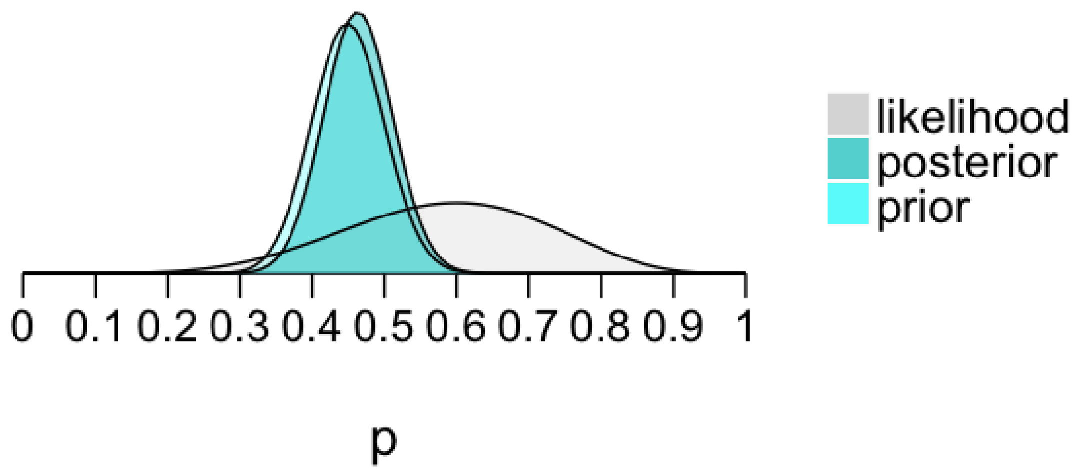


Posterior model of p

prior: $p \sim Beta(45, 55)$

likelihood: $X \sim Bin(10, p)$

Bayes' Rule:
posterior $\propto$ prior * likelihood



Getting Started with RJAGS

`RJAGS` combines the power of `R` with the `JAGS` (*Just Another Gibbs Sampler*) engine.
To get started:

- Download the `JAGS` program outside `R`
- Within `R`, install the `rjags` package

Bayesian Models in RJAGS: DEFINE

```
# DEFINE the model
vote_model <- "model{
    # Likelihood model for X
    X ~ dbin(p, n)

    # Prior model for p
    p ~ dbeta(a, b)
}"
```

- $X \sim Bin(n, p)$
- $p \sim Beta(a, b)$
- **Warning:**

  the `rjags` function `dbin()` is different

  than base `dbinom()`

Bayesian Models in RJAGS: COMPILE

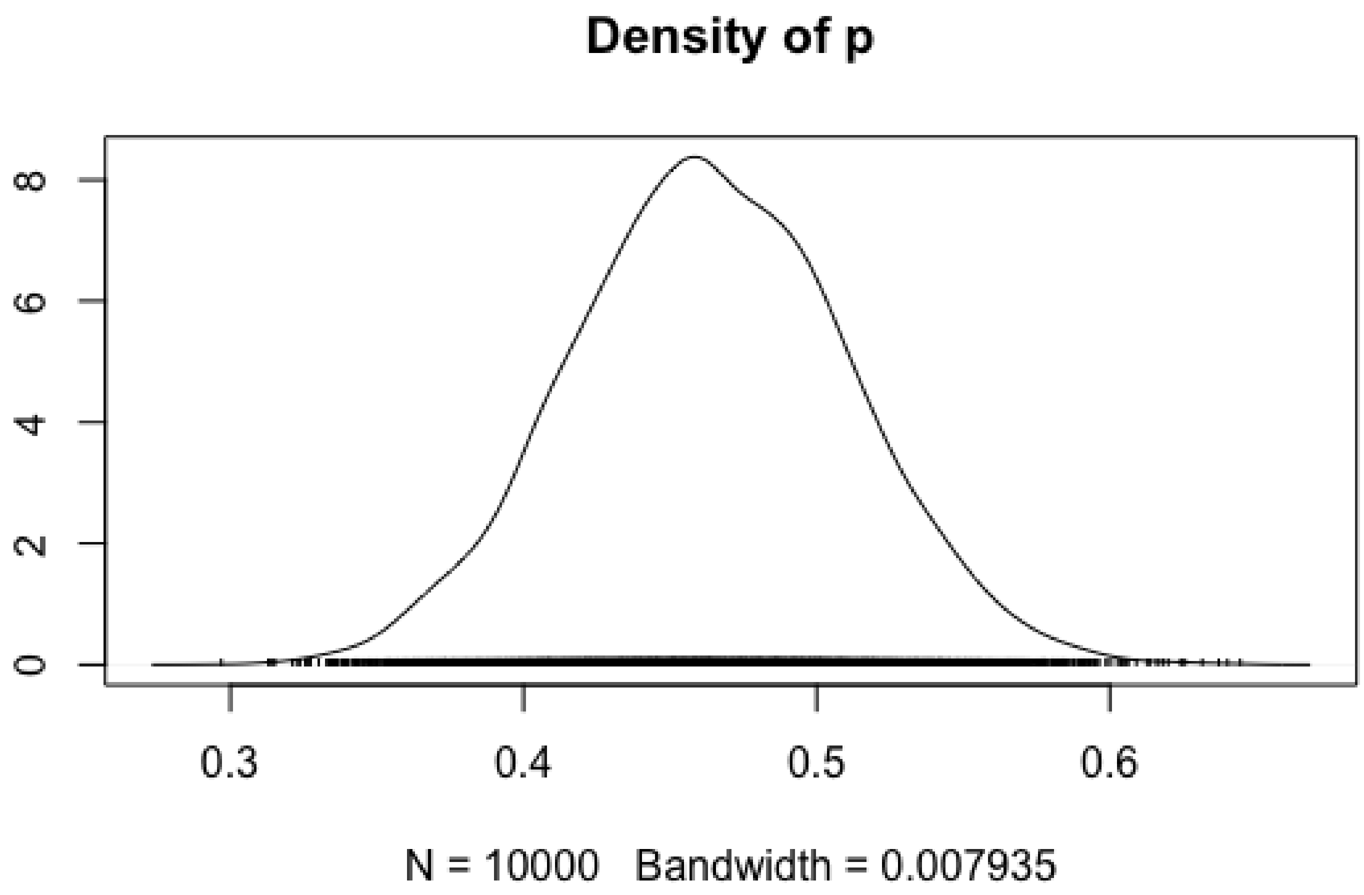
```
# DEFINE the model
vote_model <- "model{
    # Likelihood model for X
    X ~ dbin(p, n)

    # Prior model for p
    p ~ dbeta(a, b)
}"

# COMPILE the model
vote_jags_A <- jags.model(textConnection(vote_model),
    data = list(a = 45, b = 55, X = 6, n = 10),
    inits = list(.RNG.name = "base::Wichmann-Hill", .RNG.seed = 100))
```

Bayesian Models in RJAGS: SIMULATE

```
# DEFINE the model
vote_model <- "model{
    # Likelihood model for X
    X ~ dbin(p, n)

    # Prior model for p
    p ~ dbeta(a, b)
}"

# COMPILE the model
vote_jags <- jags.model(textConnection(vote_model),
    data = list(a = 45, b = 55, X = 6, n = 10),
    inits = list(.RNG.name = "base::Wichmann-Hill", .RNG.seed = 100))

# SIMULATE the posterior
vote_sim <- coda.samples(model = vote_jags,
    variable.names = c("p"),
    n.iter = 10000)
```

Bayesian Models in RJAGS: SIMULATE

```
# PLOT the simulated posterior
plot(vote_sim, trace = FALSE)
```



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