Sampling, confidence intervals, and Bayesian inference

Inference: from samples to population

We rarely measure the whole **population**, but take **samples** instead.

What's the average height in this group?

1. Write down your height and place of origin (Sevilla or other) in a piece of paper and put it in the bag.

What's the average height in this group?

1. Write down your height and place of origin (Sevilla or other) in a piece of paper and put it in the bag.
2. Now everyone **sample** 5 individuals from the whole **population** of heights.

What's the average height in this group?

1. Write down your height and place of origin (Sevilla or other) in a piece of paper and put it in the bag.
2. Now everyone **sample** 5 individuals from the whole **population** of heights.
3. Calculate the mean and 95% CI for your sample (http://graphpad.com/quickcalcs/CImean1/).

What's the average height in this group?

1. Write down your height and place of origin (Sevilla or other) in a piece of paper and put it in the bag.
2. Now everyone **sample** 5 individuals from the whole **population** of heights.
3. Calculate the mean and 95% CI for your sample (http://graphpad.com/quickcalcs/CImean1/).
4. Draw on blackboard.

What's the average height in this group?

1. Write down your height and place of origin (Sevilla or other) in a piece of paper and put it in the bag.
2. Now everyone **sample** 5 individuals from the whole **population** of heights.
3. Calculate the mean and 95% CI for your sample (http://graphpad.com/quickcalcs/CImean1/).
4. Draw on blackboard.
5. Do all CIs contain true mean height?

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150

https://pollev.com/franciscorod726

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150
- We can be 95% confident that X lies between 120 and 150

https://pollev.com/franciscorod726

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150
- We can be 95% confident that X lies between 120 and 150
- If we repeated the experiment, 95% of the time X would fall between 120 and 150

https://pollev.com/franciscorod726

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150
- We can be 95% confident that X lies between 120 and 150
- If we repeated the experiment, 95% of the time X would fall between 120 and 150
- If we repeated the experiment, 95% of the CIs would contain the true value of X

https://pollev.com/franciscorod726

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150
- We can be 95% confident that X lies between 120 and 150
- If we repeated the experiment, 95% of the time X would fall between 120 and 150
- If we repeated the experiment, 95% of the CIs would contain the true value of X
- The probability that X is greater than 0 is at least 95%

https://pollev.com/franciscorod726

If the 95% CI of X is (120, 150)...

- There is a 95% probability that X lies between 120 and 150
- We can be 95% confident that X lies between 120 and 150
- If we repeated the experiment, 95% of the time X would fall between 120 and 150
- If we repeated the experiment, 95% of the CIs would contain the true value of X
- The probability that X is greater than 0 is at least 95%
- The probability that X equals 0 is smaller than 5%

https://pollev.com/franciscorod726

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)
- A 95% CI is **NOT** 95% likely to contain the true parameter value!

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)
- A 95% CI is **NOT** 95% likely to contain the true parameter value!
- Instead, 95% of the CIs obtained with this sampling will contain the true value.

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)
- A 95% CI is **NOT** 95% likely to contain the true parameter value!
- Instead, 95% of the CIs obtained with this sampling will contain the true value.
- Like person who tells truth 95% of the time, but we can't tell if a particular statement is true.

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)
- A 95% CI is **NOT** 95% likely to contain the true parameter value!
- Instead, 95% of the CIs obtained with this sampling will contain the true value.
- Like person who tells truth 95% of the time, but we can't tell if a particular statement is true.
- It's a frequentist, long-run property.

Understanding confidence intervals

- Summarise **uncertainty** in parameter estimates.
- https://rpsychologist.com/d3/CI/ (or here)
- A 95% CI is **NOT** 95% likely to contain the true parameter value!
- Instead, 95% of the CIs obtained with this sampling will contain the true value.
- Like person who tells truth 95% of the time, but we can't tell if a particular statement is true.
- It's a frequentist, long-run property.
- To read more: Morey et al (2015)

What happens if we increase sample size?

https://rpsychologist.com/d3/CI/

- CI width *decreases*. . .

What happens if we increase sample size?

https://rpsychologist.com/d3/CI/

- CI width *decreases*. . .
- but still 5% of CIs will NOT contain true mean!

Bayesian credible intervals

- Bayesian **credible** intervals do give the probability that true parameter value is contained within them.

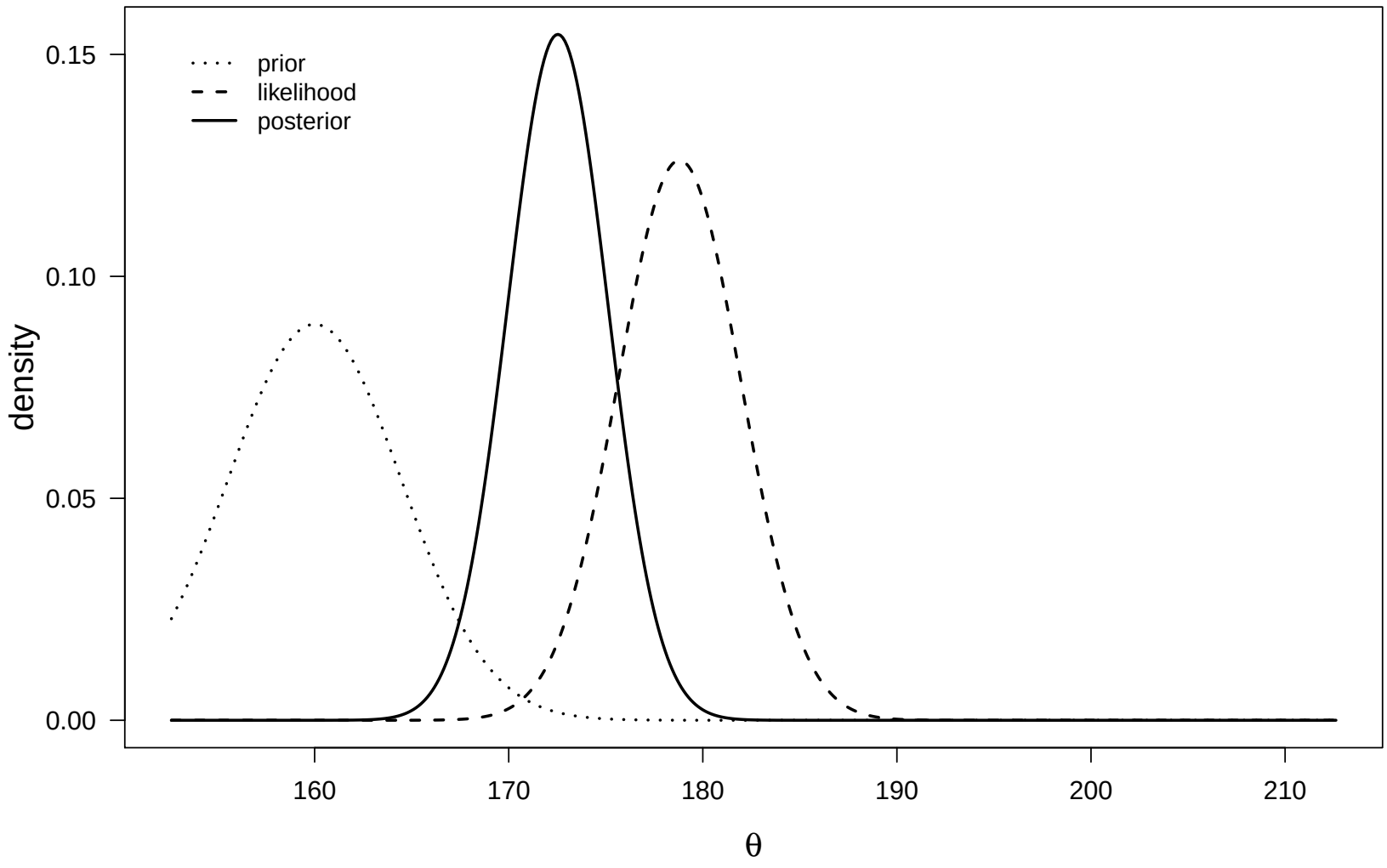
Bayesian credible intervals

- Bayesian **credible** intervals do give the probability that true parameter value is contained within them.
- Frequentist CIs and Bayesian credible intervals can be similar, but not always.

Bayesian inference: prior, posterior, and likelihood

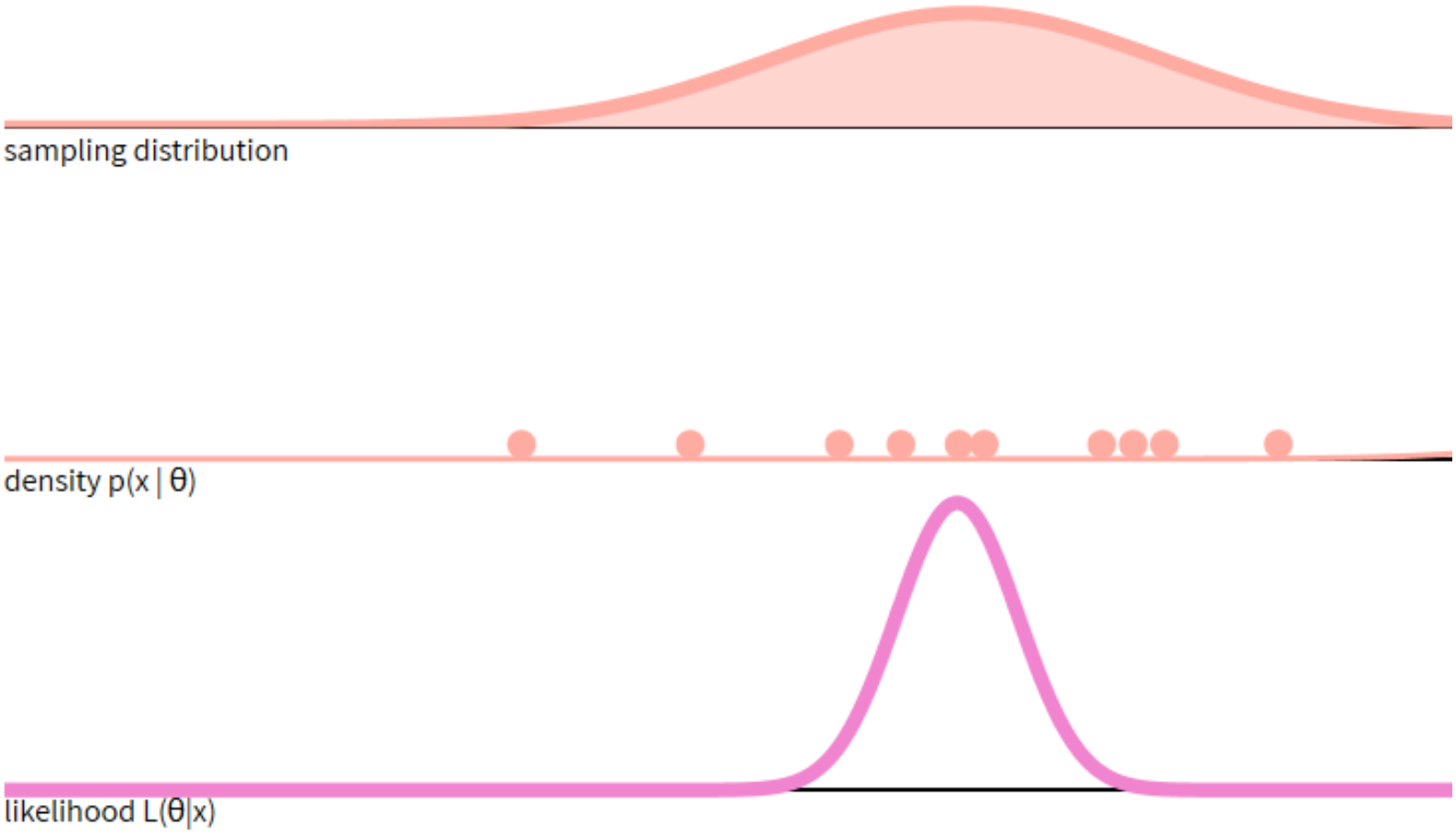
$P(H|D) \propto P(D|H)xP(H)$

Posterior $\propto$ *Likelihood* $\cdot$ *Prior*



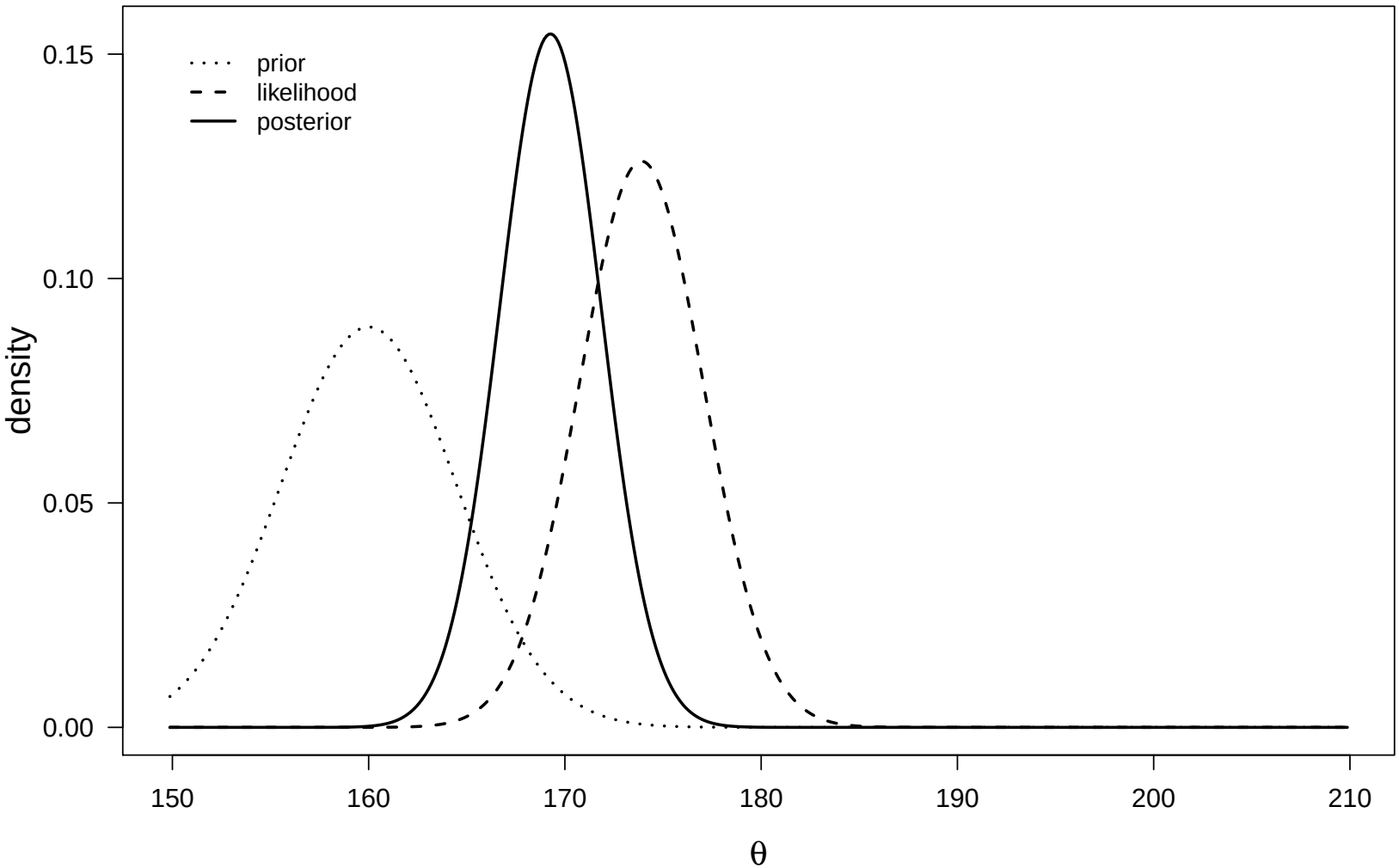
What is the likelihood?

$$L(\theta|x) = P(x|\theta)$$



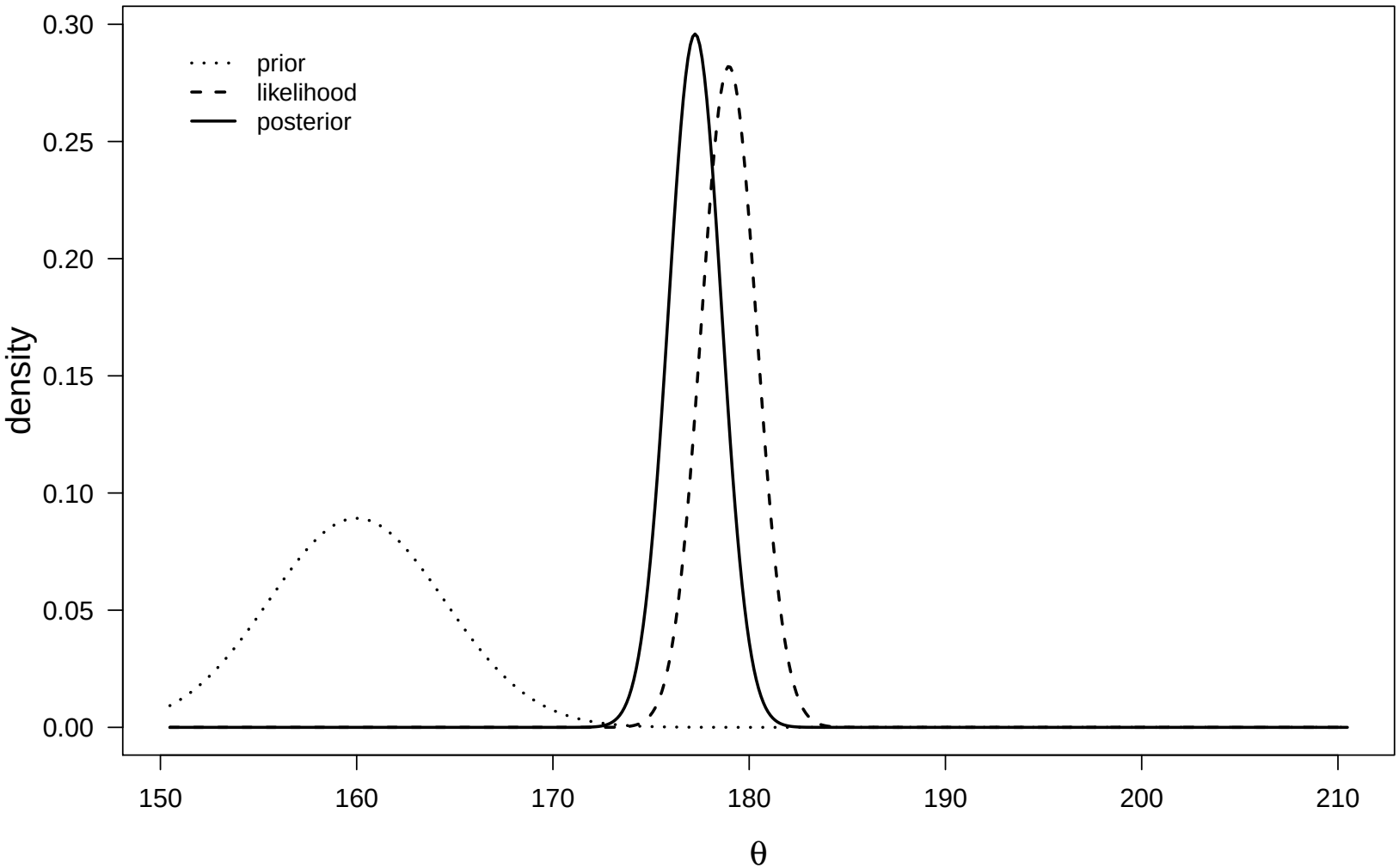
https://seeing-theory.brown.edu/bayesian-inference/index.html

Bayesian inference: prior and likelihood produce posterior




```
$posterior.mean
```

With increasing sample size, likelihood dominates prior




```
$posterior.mean
```

More apps to introduce Bayesian inference

- Bayesian Demo

More apps to introduce Bayesian inference

- Bayesian Demo
- Bayesian inference for a population mean

More apps to introduce Bayesian inference

- Bayesian Demo
- Bayesian inference for a population mean
- Normal

More apps to introduce Bayesian inference

- Bayesian Demo
- Bayesian inference for a population mean
- Normal
- Binomial

More apps to introduce Bayesian inference

- Bayesian Demo
- Bayesian inference for a population mean
- Normal
- Binomial
- Own data

More apps to introduce Bayesian inference

- Bayesian Demo
- Bayesian inference for a population mean
- Normal
- Binomial
- Own data
- Bayesian t-test