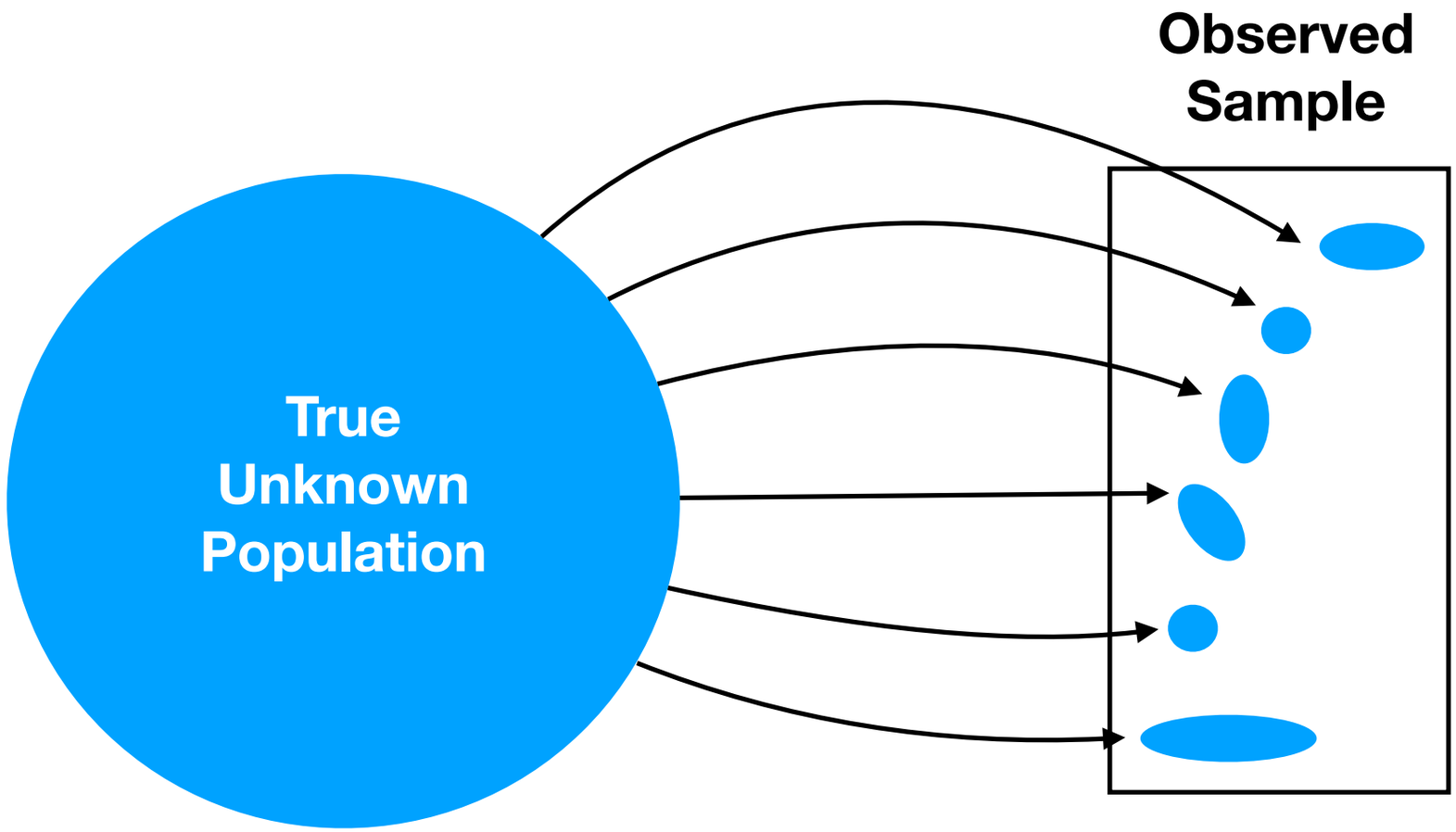
Assessing Confidence

Using Bootstrapping

Samples v Populations



Trying to learn about this . . . . . but have observed this.

Bootstrapping

Let’s say we have a sample of values…

```
[2.148, 3.141, 2.668, 3.647, 6.799, 5.728,
3.346, 3.318, 2.305, 2.051]
```

…with mean…

```
3.5151
```

How confident are we that this value is a good representation of the mean value for the entire population from which we’ve sampled?

Bootstrapping

If we know the distribution from which the data were sampled, we sometimes have a formula available to tells us about the 95% confidence interval on our estimate.

[ASIDE: What is a 95% confidence interval?]

But what if we don’t know what kind of distribution our data were drawn from?

Bootstrapping

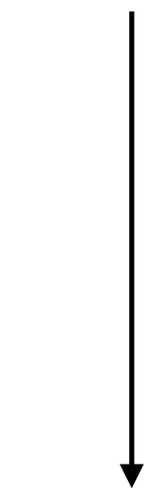
In that situation, we need to “pull ourselves up by our bootstraps”, without a formula.

Brad Efron, a Stanford statistician, gave us a procedure to do just that.

If we generate a series of pseudo-replicate datasets, by **sampling with replacement** from the original dataset, we can get an estimate of our confidence in the empirical estimate.

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

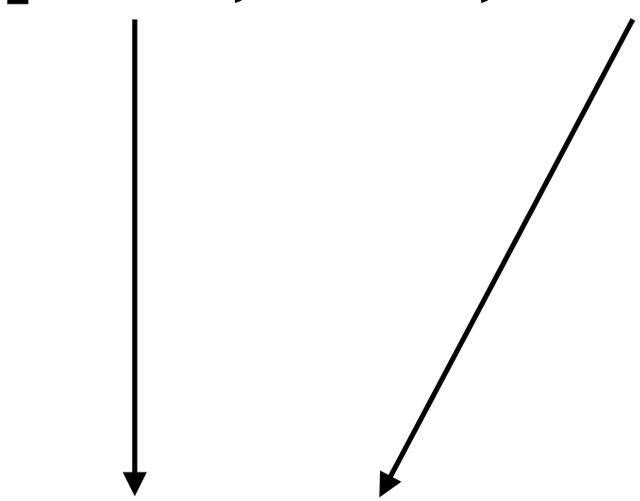


[2.148,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

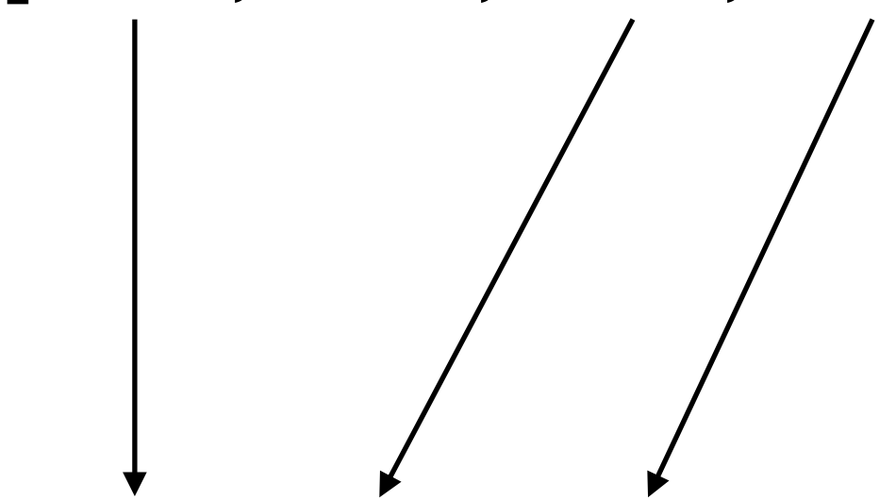


[2.148, 2.668,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

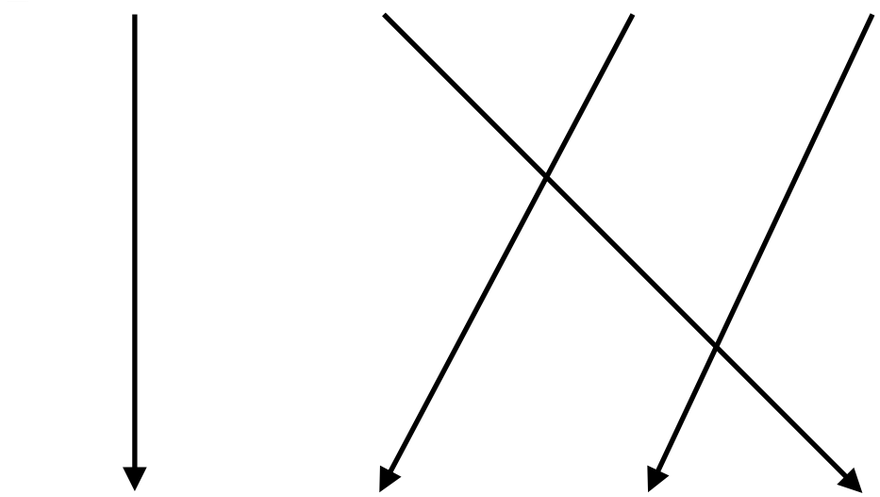


[2.148, 2.668, 3.647,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

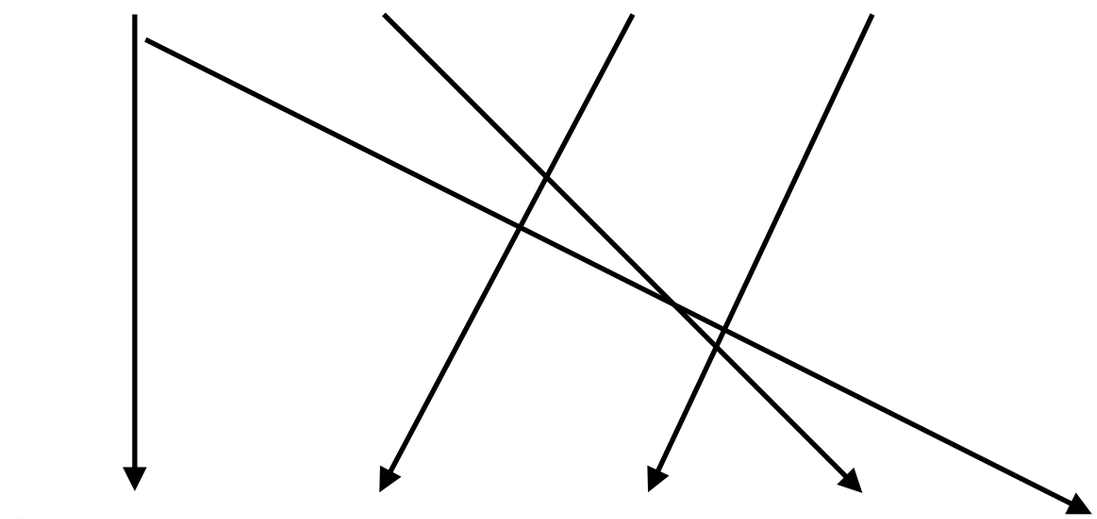


[2.148, 2.668, 3.647, 3.141,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

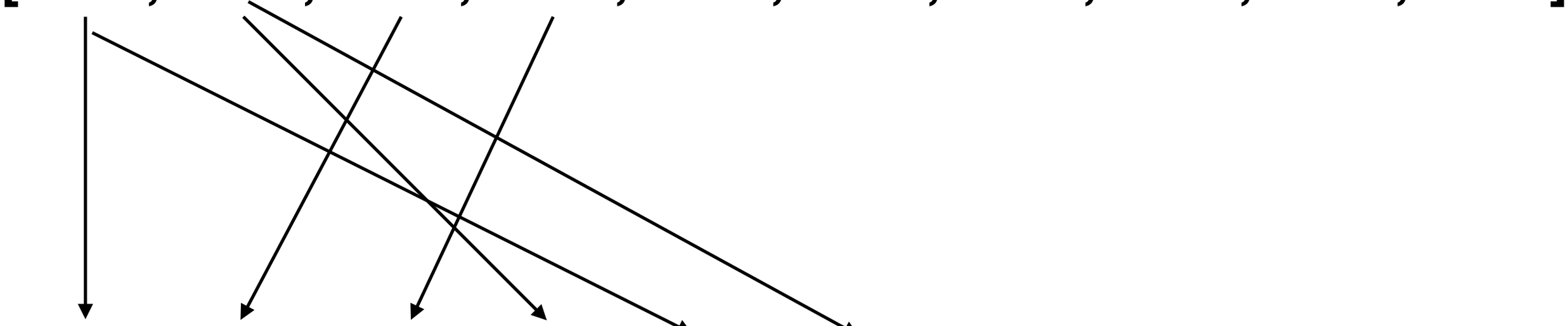


[2.148, 2.668, 3.647, 3.141, 2.148,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

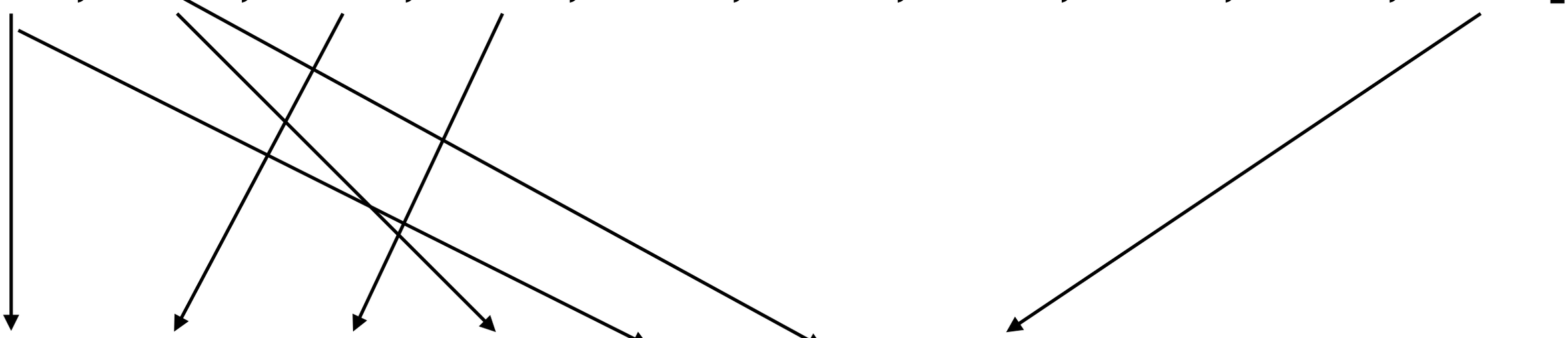


[2.148, 2.668, 3.647, 3.141, 2.148, 3.141,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

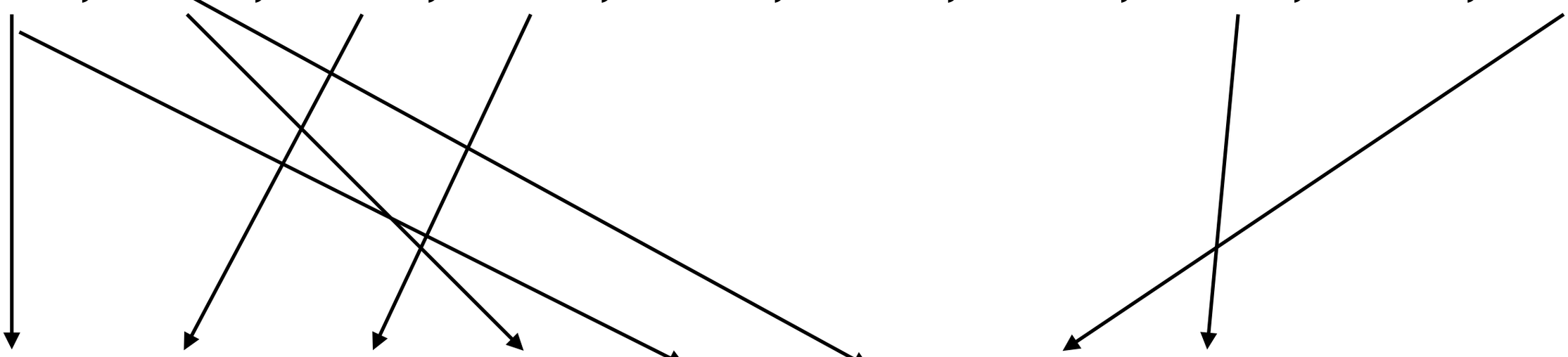


[2.148, 2.668, 3.647, 3.141, 2.148, 3.141, 2.051,

Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

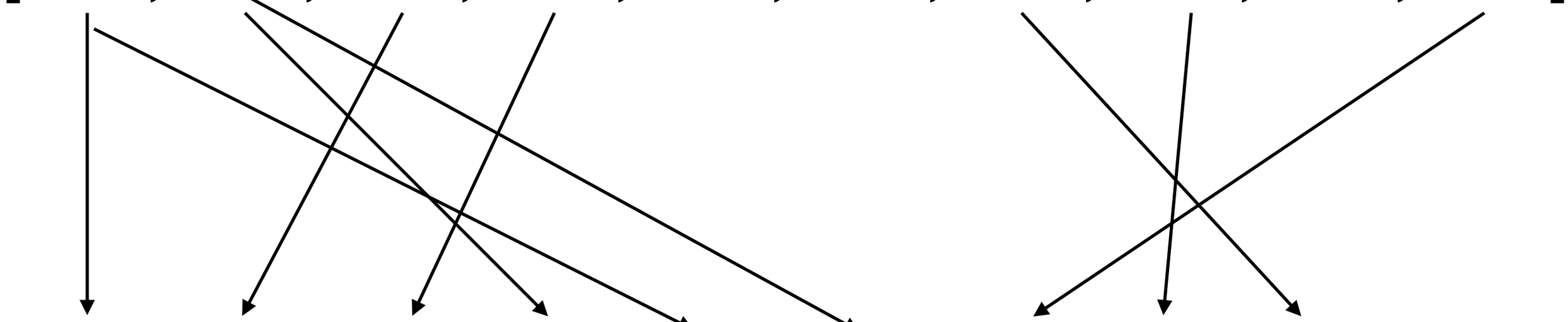


[2.148, 2.668, 3.647, 3.141, 2.148, 3.141, 2.051, 3.318,

Example Pseudoreplicate

Bootstrapping

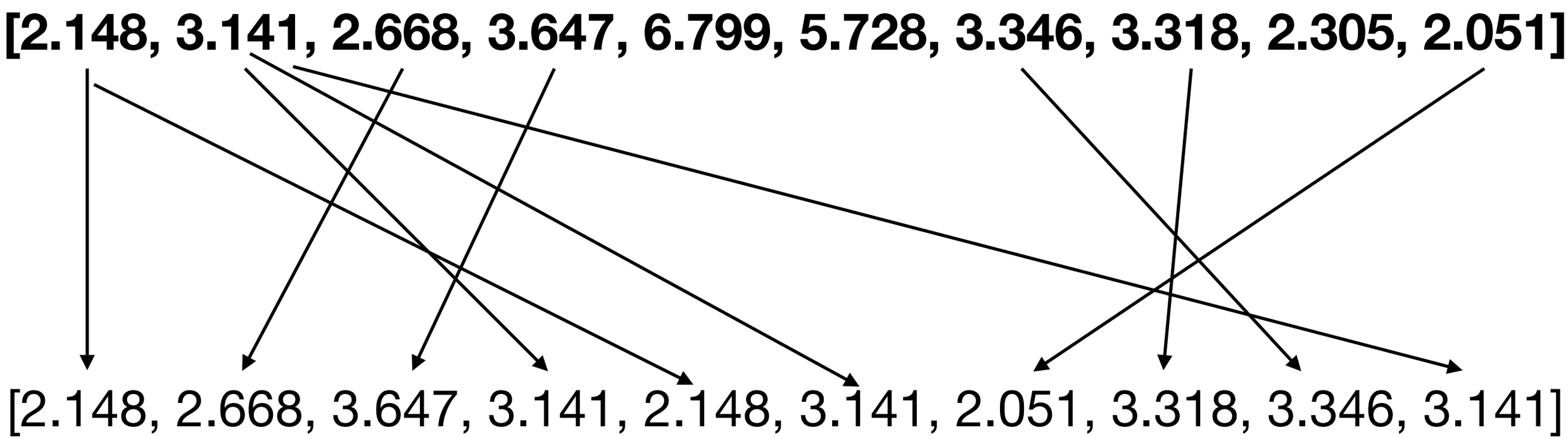
[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]



[2.148, 2.668, 3.647, 3.141, 2.148, 3.141, 2.051, 3.318, 3.346,

Example Pseudoreplicate

Bootstrapping



Example Pseudoreplicate

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

[3.318, 2.668, 2.668, 2.668, 2.305, 3.346, 2.148, 2.051, 2.668, 6.799]

[2.148, 2.148, 2.148, 3.141, 2.148, 3.318, 2.051, 5.728, 3.647, 3.647]

[6.799, 3.318, 6.799, 3.141, 6.799, 5.728, 3.346, 3.141, 2.668, 5.728]

[2.051, 6.799, 2.305, 5.728, 3.318, 3.647, 6.799, 3.141, 2.668, 3.346]

[2.668, 3.346, 3.346, 2.305, 2.148, 3.346, 3.647, 3.318, 3.346, 2.305]

[2.305, 3.318, 2.148, 3.647, 2.148, 2.668, 6.799, 6.799, 3.141, 3.141]

[3.318, 2.668, 3.318, 3.141, 5.728, 3.318, 2.305, 2.668, 5.728, 3.141]

[6.799, 5.728, 6.799, 2.051, 2.668, 2.051, 2.305, 5.728, 3.647, 3.141]

[2.051, 2.668, 5.728, 2.148, 3.318, 2.148, 2.148, 2.148, 2.305, 3.141]

[3.141, 2.305, 2.668, 3.141, 3.346, 2.148, 3.318, 2.051, 3.141, 5.728]

Bootstrapping

[2.148, 3.141, 2.668, 3.647, 6.799, 5.728, 3.346, 3.318, 2.305, 2.051]

Observed Mean: 3.5151

	Bootstrap Means
[3.318, 2.668, 2.668, 2.668, 2.305, 3.346, 2.148, 2.051, 2.668, 6.799]	3.0639
[2.148, 2.148, 2.148, 3.141, 2.148, 3.318, 2.051, 5.728, 3.647, 3.647]	3.0124
[6.799, 3.318, 6.799, 3.141, 6.799, 5.728, 3.346, 3.141, 2.668, 5.728]	4.7467
[2.051, 6.799, 2.305, 5.728, 3.318, 3.647, 6.799, 3.141, 2.668, 3.346]	3.9802
[2.668, 3.346, 3.346, 2.305, 2.148, 3.346, 3.647, 3.318, 3.346, 2.305]	2.9775
[2.305, 3.318, 2.148, 3.647, 2.148, 2.668, 6.799, 6.799, 3.141, 3.141]	3.6114
[3.318, 2.668, 3.318, 3.141, 5.728, 3.318, 2.305, 2.668, 5.728, 3.141]	3.5333
[6.799, 5.728, 6.799, 2.051, 2.668, 2.051, 2.305, 5.728, 3.647, 3.141]	4.0917
[2.051, 2.668, 5.728, 2.148, 3.318, 2.148, 2.148, 2.148, 2.305, 3.141]	2.7803
[3.141, 2.305, 2.668, 3.141, 3.346, 2.148, 3.318, 2.051, 3.141, 5.728]	3.0987

Bootstrapping

Observed Mean: 3.5151

Bootstrap Means

3.0639

3.0124

4.7467

3.9802

2.9775

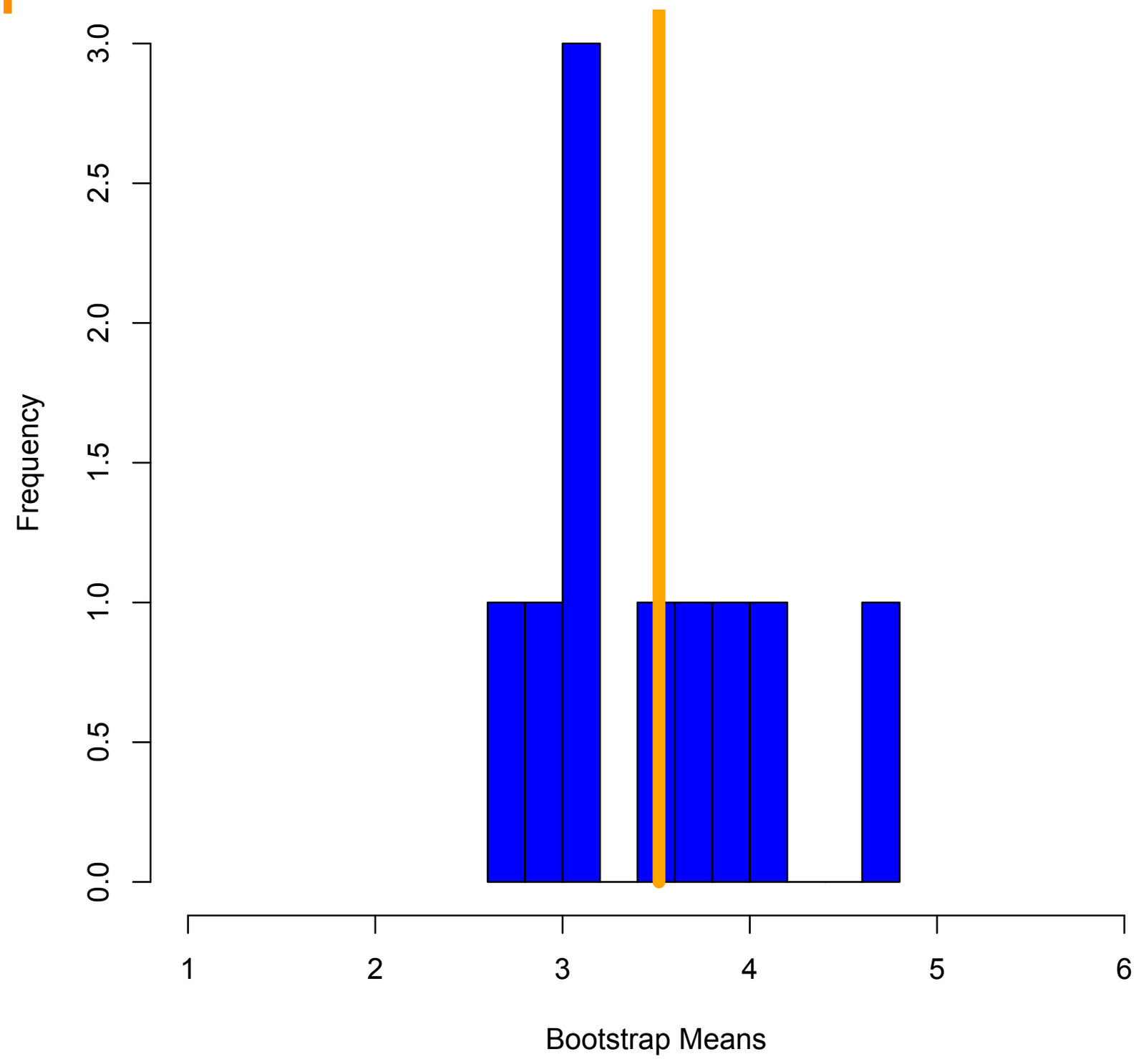
3.6114

3.5333

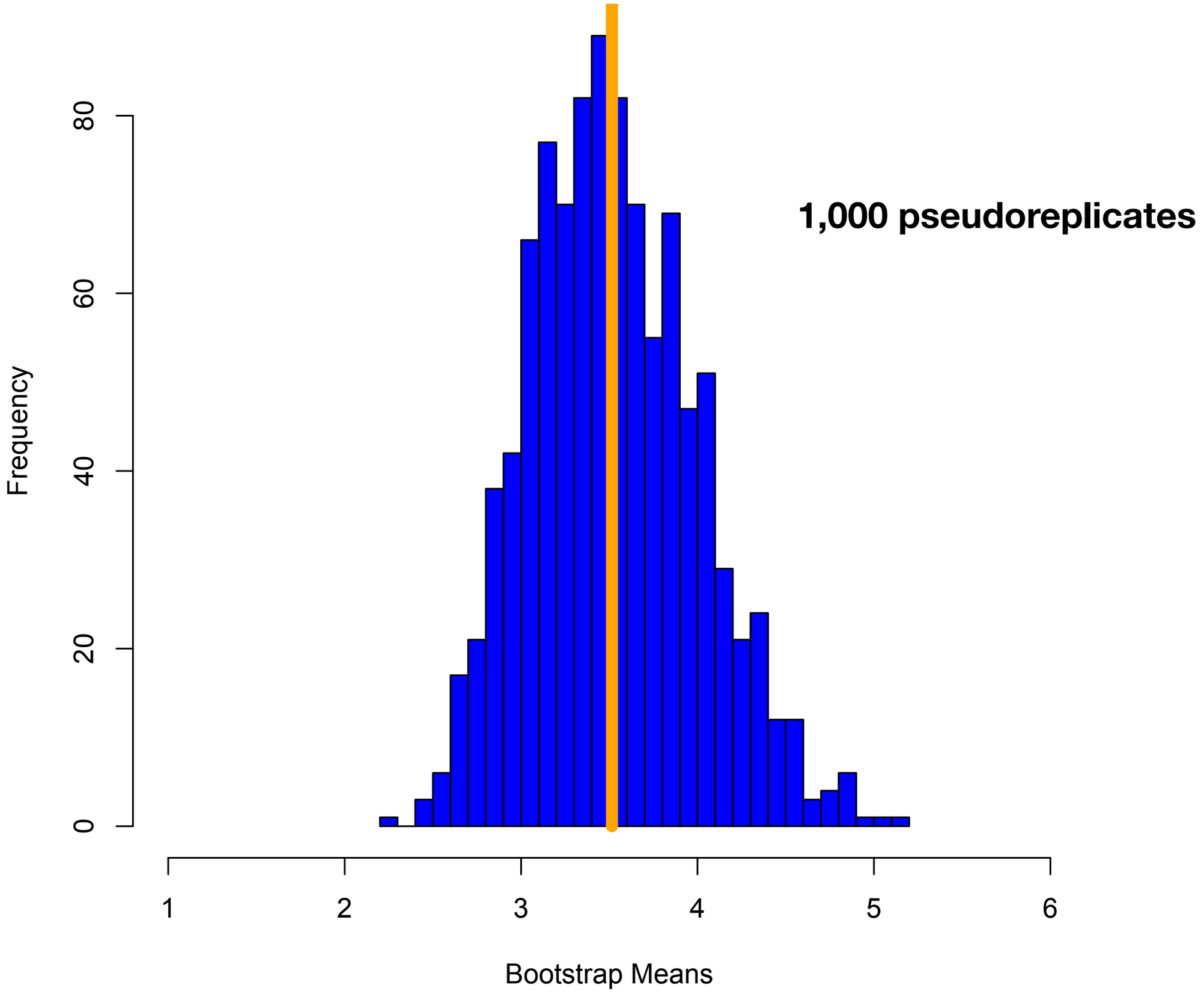
4.0917

2.7803

3.0987

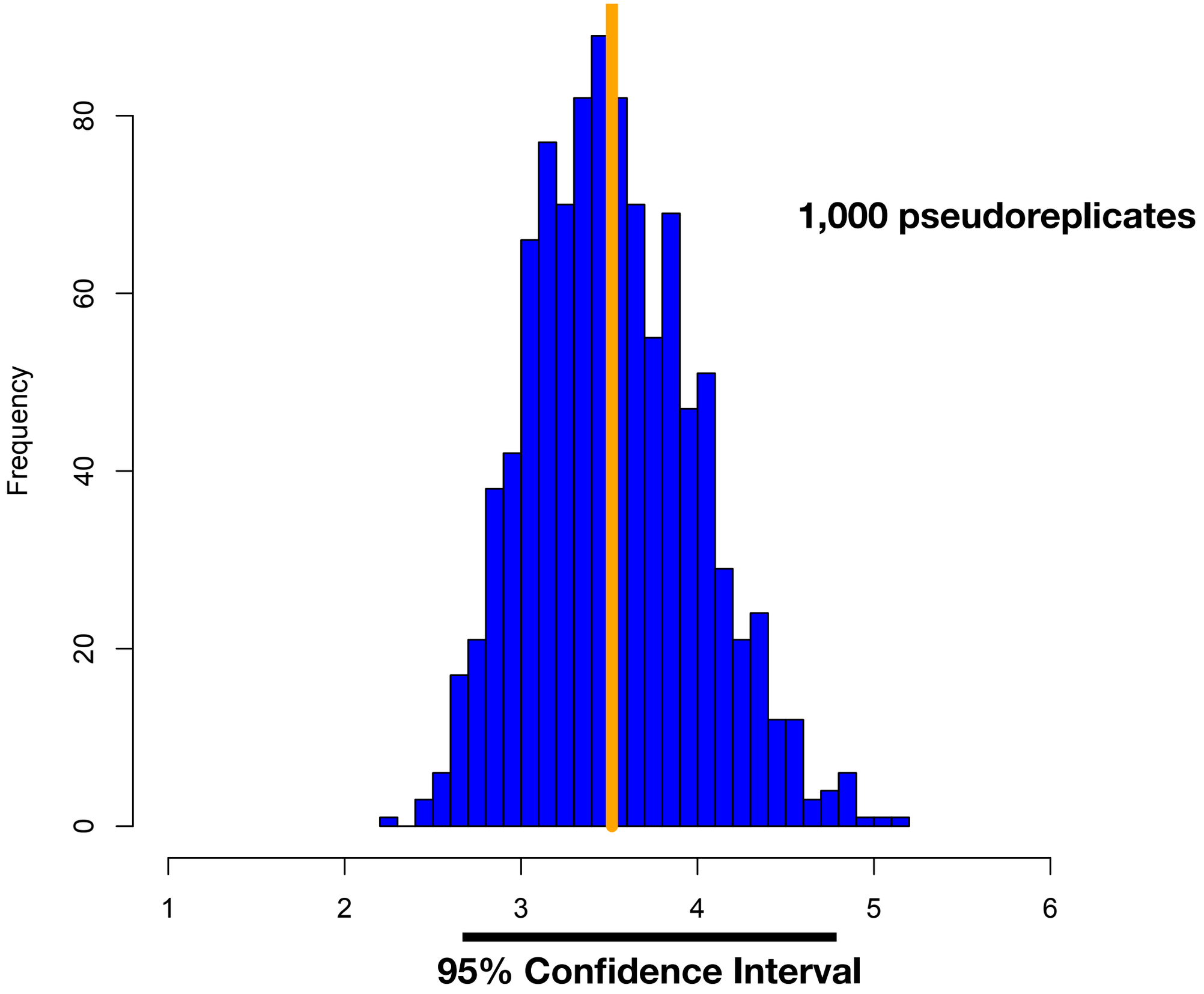


Bootstrapping



1,000 pseudoreplicates

Bootstrapping



Bootstrap Animations

https://seeing-theory.brown.edu/frequentist-inference/index.html#section3

https://www.stat.auckland.ac.nz/~wild/BootAnim/