

Notes on the book Statistical Rethinking

Jason

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Chapter 1: The Golem of Prague

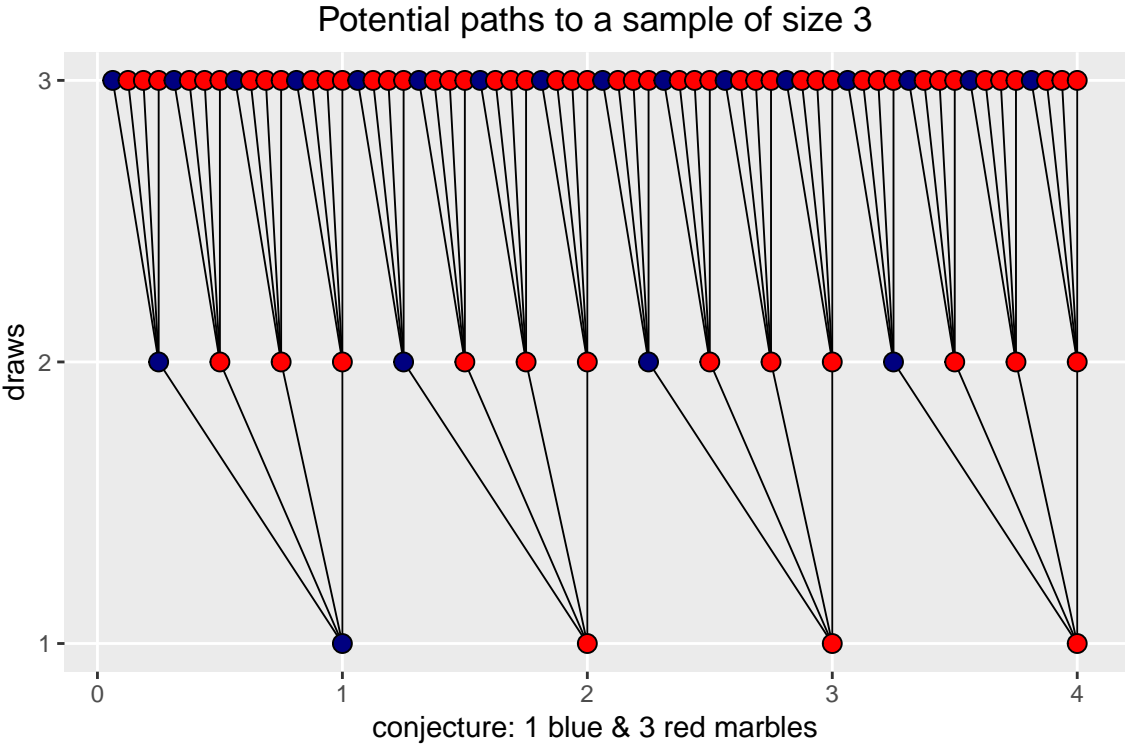
- Limitations of *deductive falsification*
 1. “Hypotheses are not models. The relations among hypotheses and different kinds of models are complex. Many models correspond to the same hypothesis, and many hypotheses correspond to a single model. This makes strict falsification impossible.” (p. 4)
 2. “Measurement matters. Even when we think the data falsify a model, another observer will debate our methods and measures. They don’t trust the data. Sometimes they are right.” (p.4)
- Main topics covered in this book...
 1. Bayesian data analysis
 2. Multilevel models
 3. Model comparison using information criteria

Chapter 2: Small Worlds and Large Worlds

Useful Example. Suppose there is a bag containing marbles. We *know* there are four marbles in the bag and that each marble may be either **red** or **blue**.

- *Prior belief:* The Bayesian approach always begins with a prior belief about the conjecture – i.e., how many **red** marbles are in the bag. To incorporate a prior belief we must assign a plausibility to each possibility. Imagine that we met the owner of the bag and they told us that there is a company that makes these bags and they do so in a way that ensure that there is a 15% chance that a bag has only 1 **blue** marble, a 50% chance that a bag has 2 **blue** marbles, a 15% chance that a bag has 3 **blue** marbles, a 10% chance that a bag has all **blue** marbles, and a 10% chance that the bag does not contain any **blue** marbles. We could use this as our prior belief about the contents of our bag.
- *Data:* Suppose we repeat the following steps 3 times: shake the bag (randomly distributing the marbles), blindly draw out a marble, note the color, and put the marble back in the bag. Now, suppose this exercise produced the following sequence of marbles **● ● ●** in that exact order (*so sequence matters*).
- *Likelihood:* We can think of the likelihood as a way to count all of the possible ways of producing this sample **given** a conjecture of what the bag looks like. Consider one possible conjecture: **● ● ● ●**. How likely is the observed sample **● ● ●** given the conjecture?

To answer this question, we count the possible ways our conjecture can generate the sample. Then we will compare the total number of ways across different conjectures as a way to evaluate which conjecture is the most likely candidate for generating $\bullet \bullet \bullet$. The following plot shows all of the possible samples that (the conjecture) $\bullet \bullet \bullet \bullet$ can produce:



From

this figure we see that there are 3 possible ways to generate the observed data. The following table lists all of the ways that the 5 possible conjectures could generate the sample $\bullet \bullet \bullet$:

Conjecture	# of ways to produce $\bullet \bullet \bullet$	% of Total
$\bullet \bullet \bullet \bullet$	$1 \times 3 \times 1 = 3$	$\frac{3}{20} = .15$
$\bullet \bullet \bullet \bullet$	$2 \times 2 \times 2 = 8$	$\frac{8}{20} = .40$
$\bullet \bullet \bullet \bullet$	$3 \times 1 \times 3 = 9$	$\frac{9}{20} = .45$
$\bullet \bullet \bullet \bullet$	$4 \times 0 \times 4 = 0$	$\frac{0}{20} = .00$
$\bullet \bullet \bullet \bullet$	$0 \times 4 \times 0 = 0$	$\frac{0}{20} = .00$

- *Bayesian updating & posterior distribution:* We update our prior information using the data, our likelihood, and multiplication. The result is a probability distribution for our model parameters, which we can use to make inferences.

Conjecture	Prior	Likelihood of ●●●	\propto Posterior	Rescaled Posterior
●●●●	.15	$\frac{3}{20} = .15$	$.15 \times .15 = .0225$	$\frac{.0225}{.275} = .082$
●●●●	.50	$\frac{8}{20} = .40$	$.50 \times .40 = .2000$	$\frac{.2}{.275} = .723$
●●●●	.15	$\frac{9}{20} = .45$	$.15 \times .35 = .0525$	$\frac{.0525}{.275} = .191$
●●●●	.10	$\frac{0}{20} = .00$	$.10 \times .00 = .0000$	$\frac{0}{.275} = .000$
●●●●	.10	$\frac{0}{20} = .00$	$.10 \times .00 = .0000$	$\frac{0}{.275} = .000$

Another example of Bayesian updating.

Chapter 3

Chapter 4