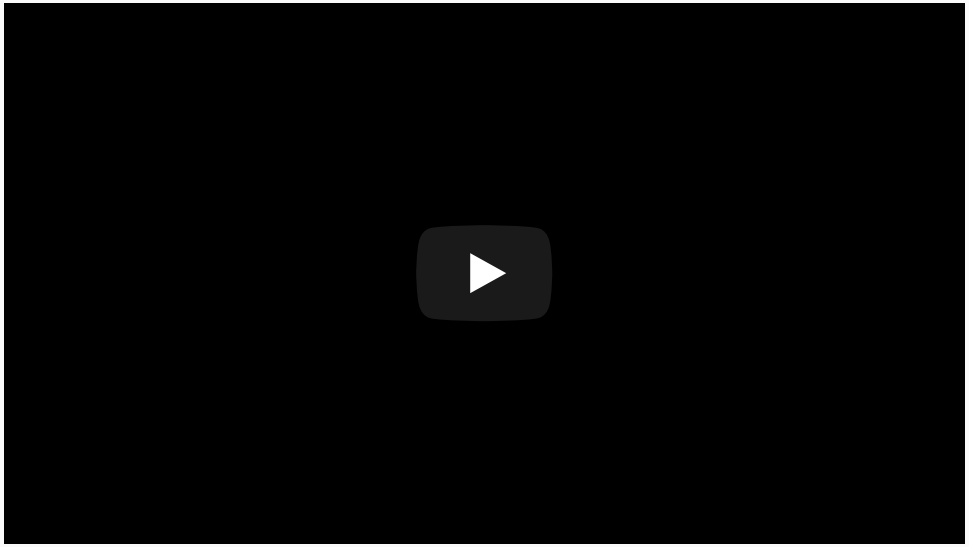
Introduction

PSYC 573

University of Southern California
January 11, 2022

History of Bayesian Statistics

- Video intro: https://www.youtube.com/watch?v=BcvLAw-JRss



- A nice popular science book by Sharon Bertsch McGrayne: *The theory that would not die*

Historical Figures

Thomas Bayes (1701--1762)

- English Presbyterian minister
- "An Essay towards solving a Problem in the Doctrine of Chances", edited by Richard Price after Bayes's death

Pierre-Simon Laplace (1749--1827)

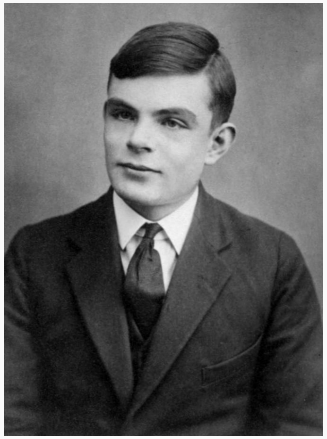
- French Mathematician
- Formalize Bayesian interpretation of probability, and most of the machinery for Bayesian statistics

In the 20th Century

- Bayesian---way to do statistics until early 1920s
- Ronald Fisher and Frequentist scholars took over
    - "The theory of inverse probability is founded upon an error, and must be wholly rejected" (Fisher, 1925, p. 10)[1]

[1]: Aldrich, J. (2008). R. A. Fisher on Bayes and Bayes' theorem. *Bayesian Analysis, 3*(1), 161--170.

Resurrection



- Alan Turing's algorithms in code breaking in World War II
- *Markov Chain Monte Carlo* (MCMC) algorithm
  - Bring Bayesian back to the main stream of statistics

Why Should You Learn About the Bayesian Way?

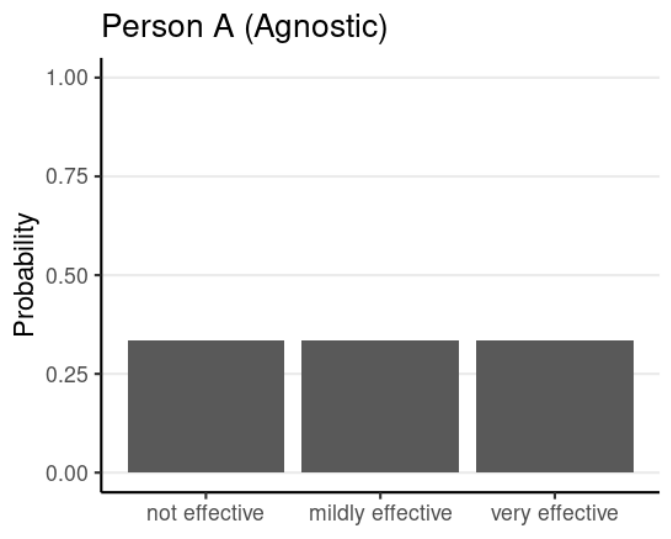
- Gigerenzer (2004): It is one tool of your statistical toolbox
- Increasingly used as alternative to frequentist statistics
- Computationally more stable for complex models
- A coherent way of incorporating prior information
    - Common sense knowledge, previous literature, sequential experiments, etc

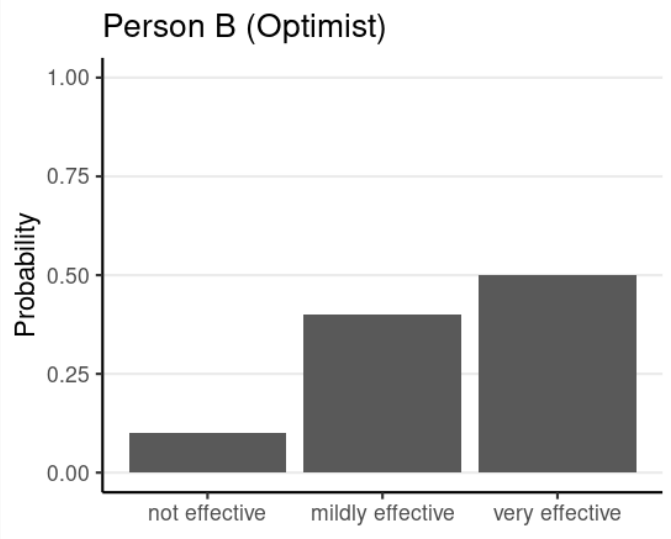
Bayesian Idea 1

Reallocation of credibility across possibilities

Hypothetical example: How effective is a vaccine?

Prior (before collecting data)

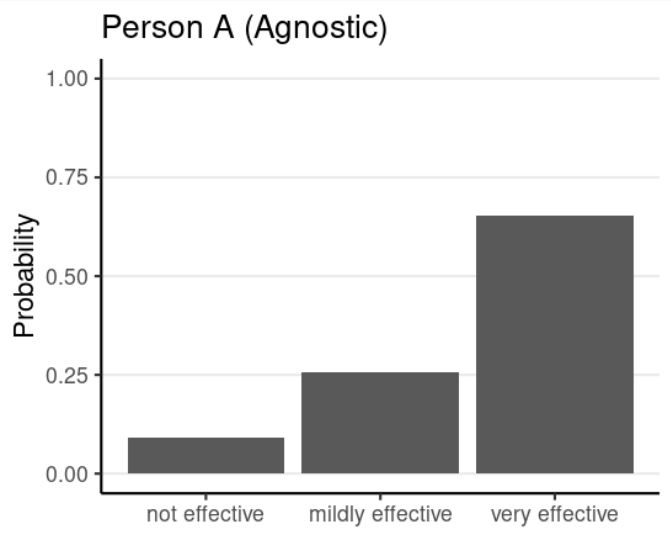


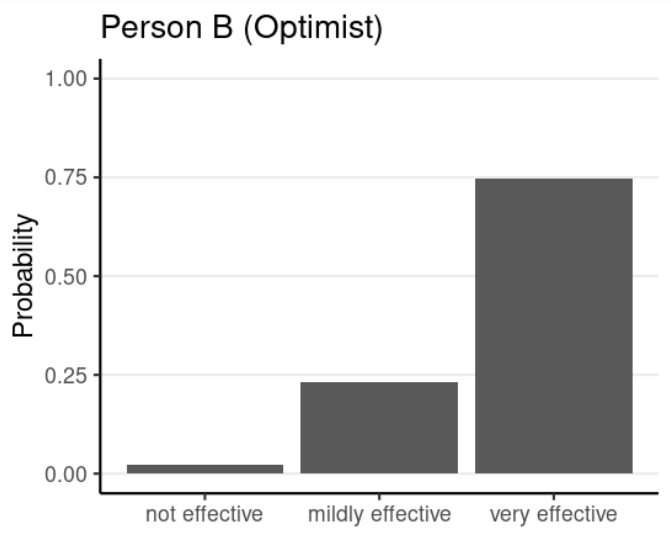


Updating Beliefs

After seeing results of a trial

- 4/5 with the vaccince improved
- 2/5 without the vaccine improved





Possibilities = Parameter Values

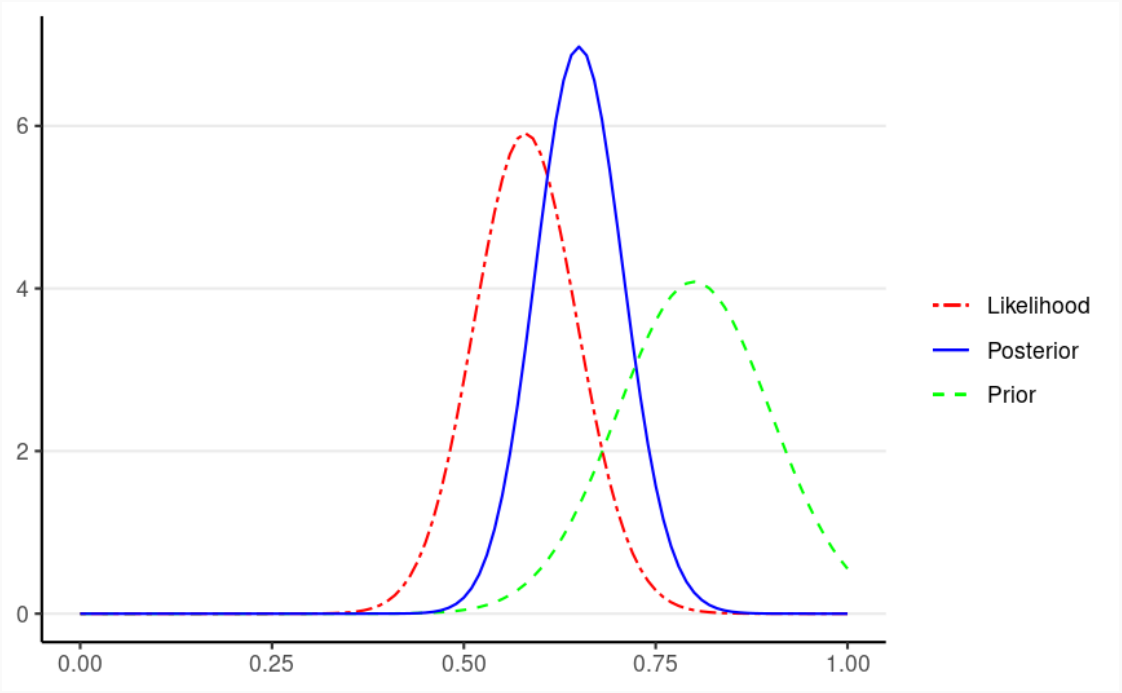
- Parameter: Effectiveness of the vaccine
- Possibilities: Not effective, mildly effective, very effective

> Here the parameter is a discrete variable

- Parameter: Risk reduction by taking the vaccine
- Possibilities: $(-\infty, \infty)$ (Any real number)

> Here the parameter is a continuous variable

Using Bayesian analysis, one obtains updated/**posterior probability** for every possibility of a parameter, given the **prior** belief and the **data**



Steps of Bayesian Data Analysis

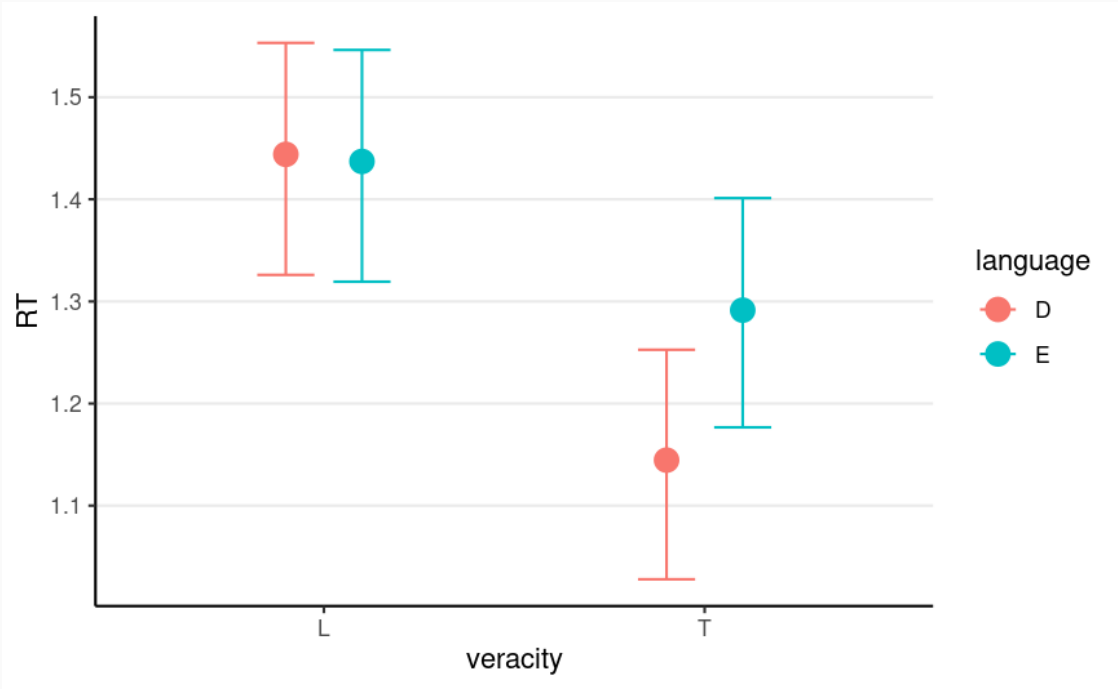
"Turning the Bayesian crank"

1. Identify data
2. Define a mathematical model with parameters
3. Specify priors on parameters
4. Obtain and interpret posterior distributions of the parameters
5. Posterior predictive check

Example

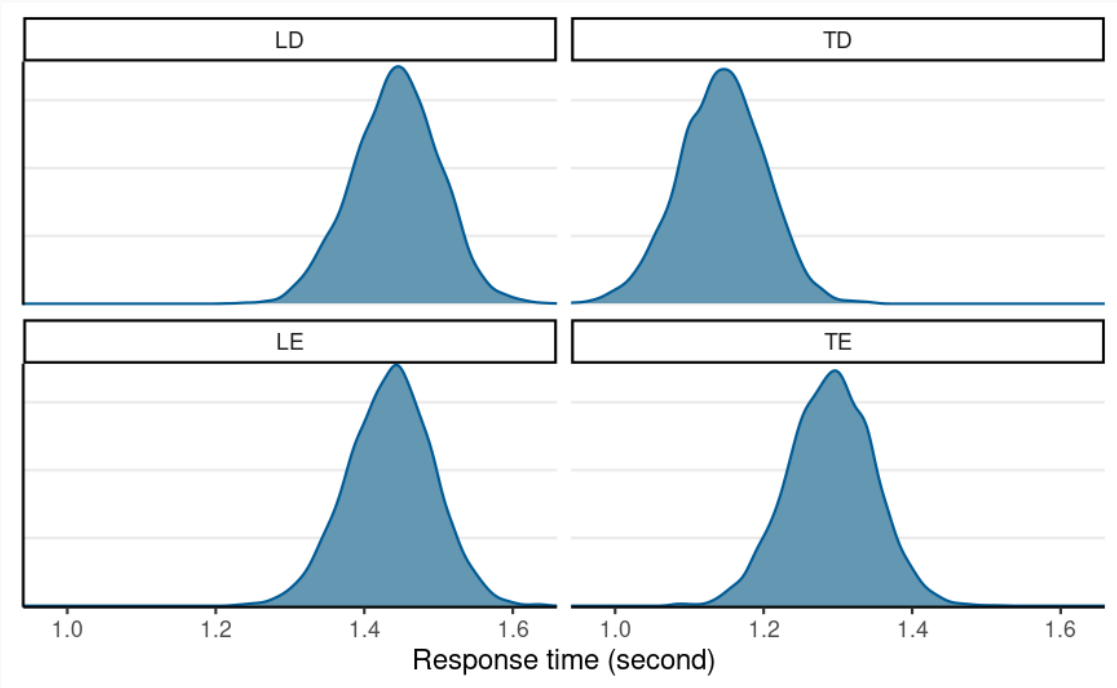
Frank et al. (2019, Cognition and Emotion)

- Response time for 2 (Dutch--native vs. English--foreign) $\times$ 2 (lie vs. truth) experimental conditions

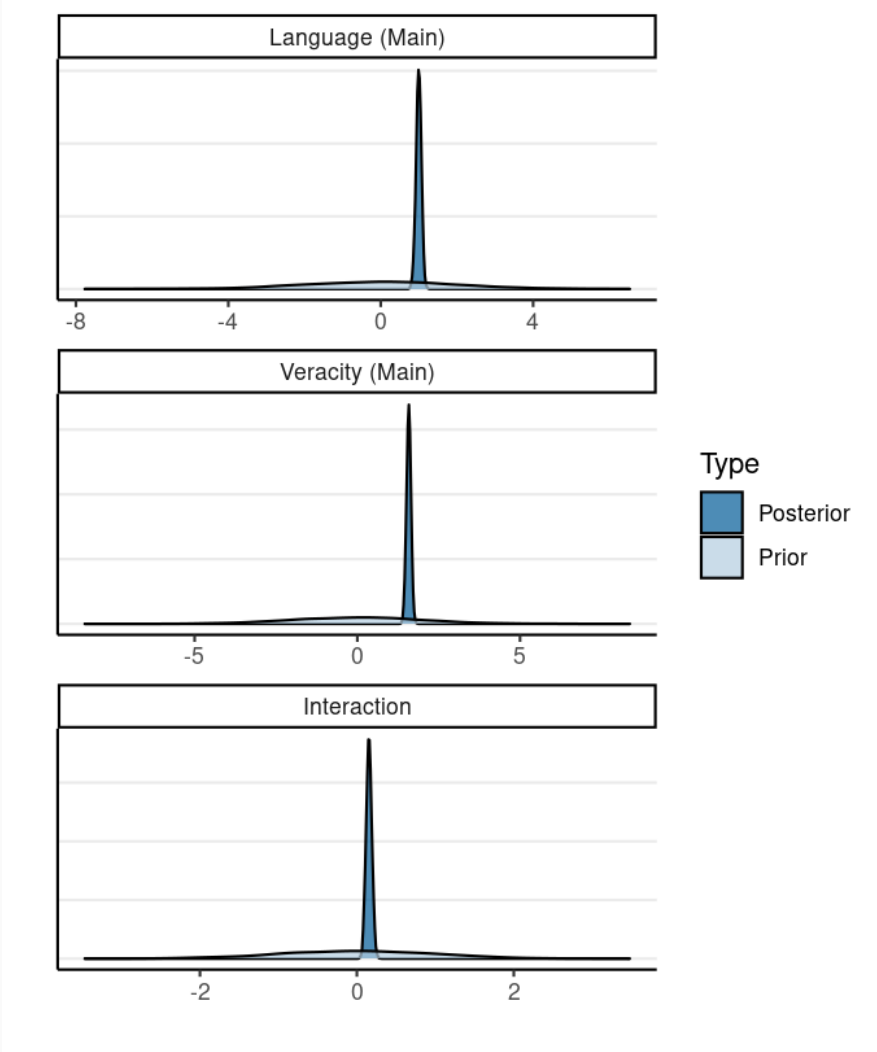


Posterior of Mean RTs by Conditions

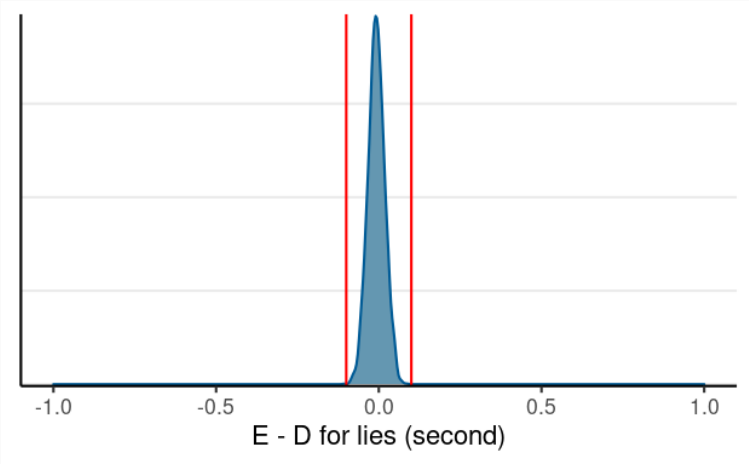
L = Lie, T = Truth; D = Dutch, E = English



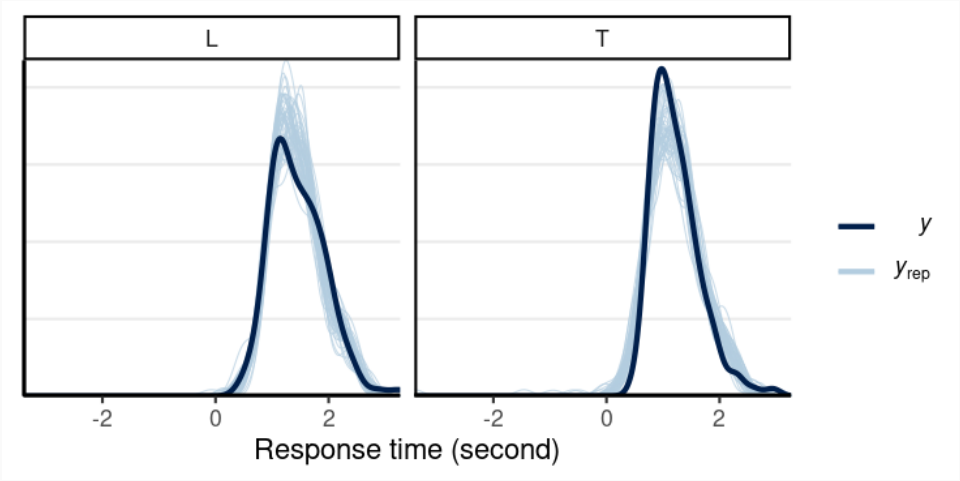
From Priors to Posteriors



Accepting the Null



Posterior Predictive Check



Multiple Experiments

Kay, Nelson, & Hekler (2016, p. 4525, https://dl.acm.org/doi/abs/10.1145/2858036.2858465)

Syllabus

Homework 1