

# Basic Bayes

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### 1 Bayes Theorem:

$$P(H|D) = \frac{P(D|H)P(H)}{P(D)}$$



Figure 1: Thomas Bayes

### 2 In Words:

posterior  $\propto$  likelihood  $\times$  prior

### 3 Benefits

1. In Bayesian analysis, we are *not* assessing the plausibility of the data ( $P(D|H)$ ), given the assumption of a null hypothesis  $H_0$  : parameter value = 0. This feature of Bayesian analysis has a few key implications:
  - We are actually estimating—the probability of a particular hypothesis given the data—what we often *think* we are estimating in Frequentist analysis. Thus, after conducting a Bayesian analysis, we can simply say, “The probability of our hypothesis ( $P(H|D)$ ) given the data is  $x$ ,” rather than engaging in complicated statements about “Were the null hypothesis to be true, we estimate that it is  $p$  likely that we would see data as extreme, or more extreme, than we actually observed.”
  - Because we are directly estimating the probability of hypotheses, we can not only evaluate the probability of the null hypothesis ( $H_0$ ), but also accept the null hypothesis ( $H_0$ ), something that we are never supposed to be able to do in frequentist analysis. Being able to accept the null hypothesis may have implications for *equivalency testing* and *theory simplification* and may reduce publication bias, if we are not always looking for ways to reject  $H_0$ .

2. In Bayesian analysis, we are able to incorporate *prior information* ( $P(H)$ ). Prior information may reflect particular beliefs about the likely value of a parameter, and have higher (vague prior) or lower (informative prior) levels of uncertainty. Prior information may come from a number of sources:
  - Prior history of a project.
  - Meta-analyses or systematic reviews of the question being considered.
  - Expert knowledge, or community beliefs or wisdom.
3. Because Bayesian estimation relies on *Markov Chain Monte Carlo* (MCMC) simulation methods, Bayesian methods may perform better when there are small samples. In multilevel modeling, Bayesian methods may perform better when there are small *level 1* and/or *level 2* samples.