Role of Priors in Bayesian Analysis

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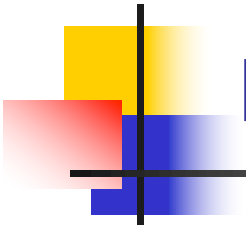
Based on work in progress with Bill Starbuck, Mark Hansen, and Jeff Dotson



Priors in Bayesian analysis

- What are priors?
  - Prior distributions are predictions about outcome distributions.
- What functions do they serve?
  - Required for Bayesian analysis.
  - Priors are updated using empirical observations.
  - Priors *can* influence results.
  - Priors should reflect what we already know about effects.

Bayesian Analysis
Step 1: Specify Prior Distribution

- How to specify a "prior" probability distribution for parameter values?
- Alternative approaches to specify and justify priors
  - Uninformed priors
  - Priors from previously published empirical studies
  - Priors based on theories
  - Sequential priors
  - Priors from experts and knowledgeable individuals
- Next: Brief outlines of each approach!

[no comprehensive treatment]

(1) Uninformative priors

- Used when researchers nothing or very little about the study phenomenon
- Uniform priors:

  All outcomes are equally likely
- Weakly informative (locally uniform) priors:

  Centered with large assigned variances
- Currently, uninformative priors are frequently used and default in statistical software [easy option]

Limitations of uninformative priors

- Makes strong assumptions that are frequently unrealistic based on what we already know about the phenomenon [e.g., prior research]
- Use as "defaults" encourages ritualized applications instead of careful analyses and adjustments (software)
- Recommendation:
  - Use only when very little or no prior knowledge
  - Justify distrust in existing evidence and previous research
  - Use in cases of data dominance
  - Useful benchmark to evaluate impact of "other" priors

(2) Priors derived from published empirical research

- Use results of available empirical studies to estimate priors (= accumulation of knowledge across studies)
- Potential challenges
  - Current lack of exact replications
  - Dissimilarity of prior related studies
  - Trust in prior studies (e.g., replication crisis)
- <u>Recommendation:</u>
  - Aggregate from a few carefully selected studies
  - Meta analyses (Aguinis et al., 2011)

(3) Priors based on theories

- Feasible for quantified theories that provide for uncertainty
- Recommendation:
  - Powerful to incorporate established knowledge
  - … but translating abstract and vague management theories into specific outcome distributions often challenging

(4) Sequential priors

- Priors based on data collected in an earlier stage of a sequential data-collection process
  - Bootstrapping of limited data (Singh and Xie, 2010)
  - Markov matrices (Doucet et al., 2000)
- Relevant approach in important emerging empirical contexts
  - Big data
  - Continuous data collections
- <u>Recommendation:</u>
  - Powerful in iterative and multi-stage research designs

(5) Elicit priors from experts and lay people

- Priors based on the intuitions of experts or knowledgeable lay people, not the researchers
- Challenges of capturing individuals' intuitions
  - Recruiting individuals
  - Individuals' perception biases
  - Translating perceptions into probability distributions
- <u>Recommendation:</u>
  - Training of subjects
  - Use graphic computer-based systems
  - Emerging advanced elicitation strategies (O'Hagan et al.)

[secondary benefits]

General Conclusions

- Bayesian analyses foster scientific progress by providing a systematic way to integrate what we already know into analyses of new data.
- **"Priors" are an opportunity!**
- … interpreting data using carefully chosen priors promises more accurate posterior distributions and stronger contributions to theory development.
- **"Priors" are an advantageous Bayesian feature!**