Bayesian Models in Psychology

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Lab 1 | Introduction

About me

- Wiktor Soral, PhD
- social psychologist
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- Course website: https://github.com/wsoral/bayesian_models
- Office hours (room 300): Monday 12:00-14:00, Thursday 11:00-13:00
- Or by appointment

About the course

- (mostly self-contained) course of the basics of Bayesian methods
- focused on practical aspects of implementation (with R)
- lab format with (mostly) real-world psychological examples
- based (to great extent) on the book by John Kruschke "Doing Bayesian Data Analysis"

About the course

- Students are allowed to miss 2 classes without excuse, 2 more classes in case of excuse, but will not pass the course in case of more than 4 absences.
- Assessment methods: **home assignments** (30%), **midterm exam** (30%), **final exam** (40%)
- Exams will be based on the selected chapters from the handbook and lab exercises
- Grading:

Grade	5!	5	4.5	4	3.5	3	2 (fail)
Points	*95%+*	*90-94%*	*80-89%*	*70-79%*	*60-69%*	*50-59%*	*below 50%*

Replication crisis in psychology

- Only one third to one half of published psychological effects replicate: http://science.sciencemag.org/content/349/6251/aac
- Infamous frauds in the field of social psychology: http://www.apa.org/science/about/psa/2011/12/diederik-stapel.aspx
- BASP bans p-values: http://www.nature.com/news/psychology-journal-bans-p-values-1.17001

Problems with Null Hypothesis Significance Testing (NHST) 1

- In NHST we claim to obtain significant effect if we obtain a *p-value* less than some threshold - usually .05

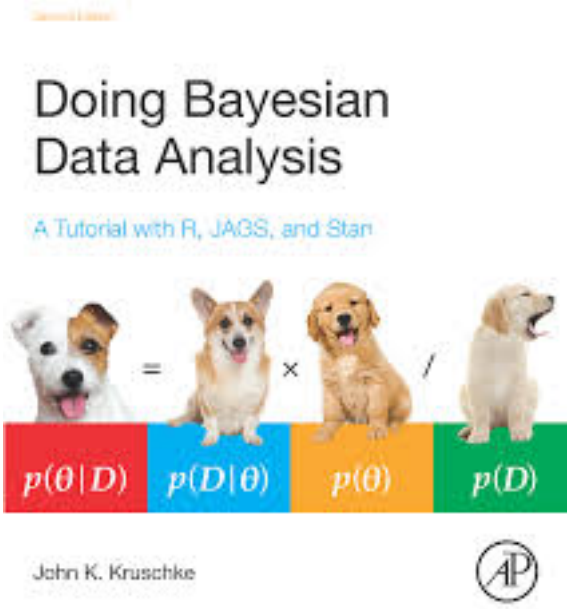


Figure 1: Puppies book

- What this *p-value* means?
- *P-value* should not be treated as a direct measure of evidence for our hypothesis
- We should rather use effect size value, e.g. Cohen's d. However it is not very intuitive.

Problems with Null Hypothesis Significance Testing (NHST) 2

- How should we set up the threshold for *p-value* ($p < .10$, $p < .05$, $p < .01$, or $p < .001$)?
- With *p-value* we cannot prove that there is no difference, or that the correlation is negligible.
- Suppose you conducted 4 studies and each time you obtained some interesting effect. However, you failed to reject null hypothesis in Study 5. What should you do?

Why Bayesian statistics? 1

- Bayesian approach (BA) offers an alternative to classical approach
- BA allows to quantify degrees of uncertainty about every possible aspect of data analysis
- BA views probability in a subjective manner - *Bayesian p-value* can be interpreted as measure of confidence in some hypothesis
- BA does not constrain hypothesis testing to rejecting null hypothesis - it can be used to quantify evidence for no effect

Why Bayesian statistics? 2

- BA allows to incorporate previous knowledge (e.g. from previous studies) in the process of hypothesis testing
- BA allows to deal quite easily with complex modeling tasks, and violated assumptions
- BA requires smaller sample sizes than classical approach
- BA is better in making predictions, and can advance us in the process of decision making

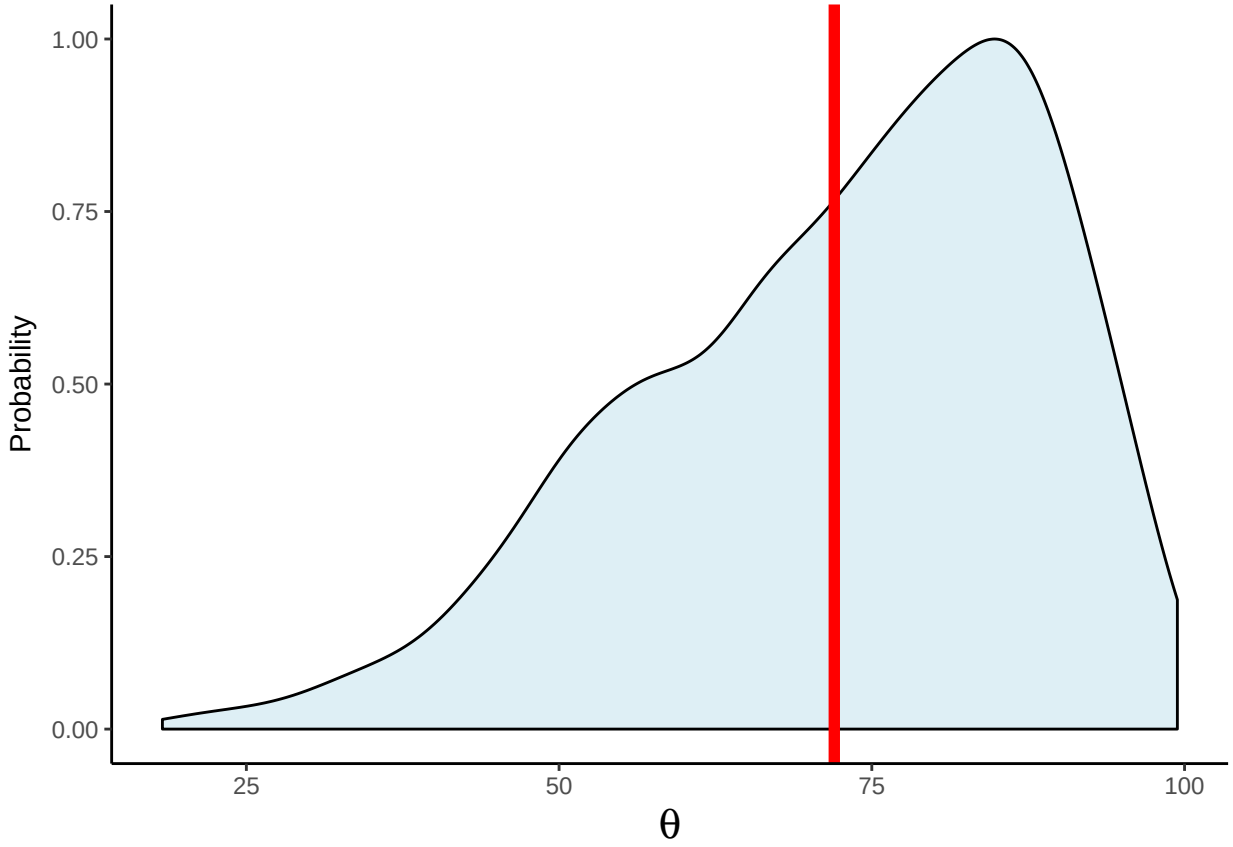
Bayesian vs. frequentist approach | Interpretation of probability

- *Frequentist* - observed result from infinite series of trials performed or imagined under identical conditions
- *What is the probability that Poland will win the nearest FIFA World Cup?*
- *Bayesian* - probability is the researcher "degree of belief" before or after the data are observed

Bayesian vs. frequentist approach | What is fixed and variable?

- *Frequentist* - data are iid random sample from continuous stream. Parameters are fixed by nature
- *Bayesian* - data are observed and so fixed by the sample generated. Parameters are unknown and described distributionally

Bayesian vs. frequentist approach | What is fixed and variable?



Probability - brief, informal and intuitive recap

- Suppose we are interested in sleeping disorder (SD) among undergraduate students
- We ask a sample of students and find 8 undergrads who report SD, and 12 who don't report SD
- A ratio of undergrads with SD to undergrads without SD is then $\frac{8}{12} \approx 0.667$ - we called it odds
- Probability of $P(SD) = \frac{odds}{1+odds} = \frac{0.667}{1+0.667} \approx 0.40$

Probability - recap

	SD	no SD	*Total*
Psychology	4	6	*10*
Journalism	2	8	*10*
Total	*8*	*12*	*20*

Probability - recap

	SD	no SD	*Total*
Psychology	0.2	0.3	*0.5*
Journalism	0.1	0.4	*0.5*
Total	*0.4*	*0.6*	*1.0*

- We call $P(SD = x)$ and $P(faculty = y)$ marginal probability
- We call $P(SD = x \; and \; faculty = y)$ joint probability
- Recall that if $P(SD = x) \times P(faculty = y) = P(SD = x \; and \; faculty = y)$ for every value of x and y, the two variables are independent.
- Otherwise they are conditionally dependent

Probability - recap

	SD	no SD	*Total*
Psychology	0.2	0.3	*0.5*
Journalism	0.1	0.4	*0.5*
Total	*0.4*	*0.6*	*1.0*

- We call $P(SD = x|faculty = y)$ conditional probability
- $P(SD = x|faculty = y) = \frac{P(SD=x \; and \; faculty=y)}{P(faculty=y)}$
- $P(faculty = y|SD = x) = \frac{P(SD=x \; and \; faculty=y)}{P(SD=x)}$
- What is a conditional probability of SD for psychology undergrads?
- What is a conditional probability of SD for journalism undergrads?

Bayes theorem

	SD	no SD	*Total*
Psychology	0.2	0.3	*0.5*
Journalism	0.1	0.4	*0.5*
Total	*0.4*	*0.6*	*1.0*

- Bayes theorem is a simple result that allows us to invert conditional probabilities, e.g. computing $P(SD = x|faculty = y)$ from $P(faculty = y|SD = x)$ without knowing a joint probability
- $P(faculty = y|SD = x) = \frac{P(SD=x|faculty=y) \times P(faculty=y)}{P(SD=x)}$