Bayes factors:
A 're-volution' in psychology
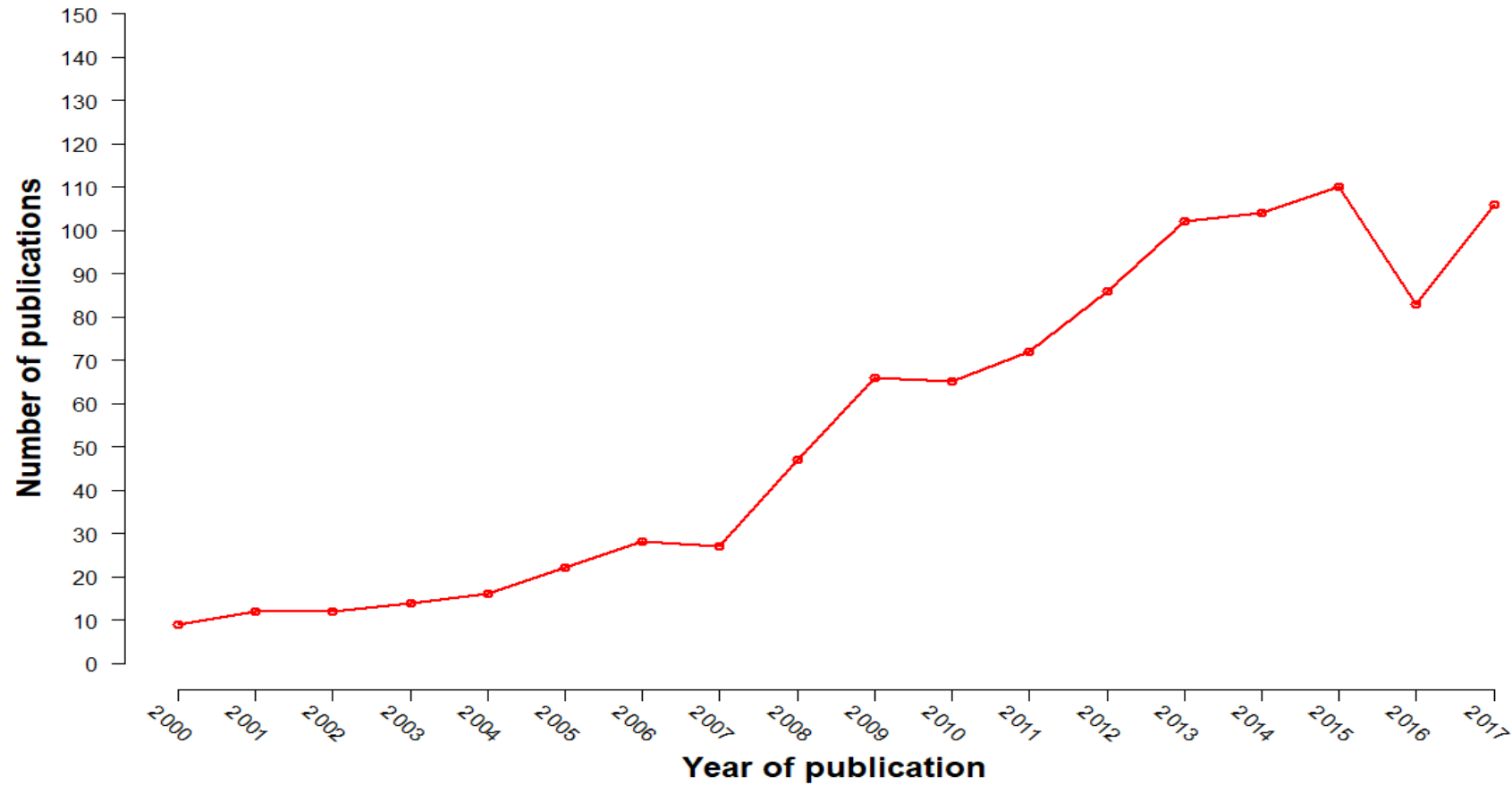
Geoff Patching

Department of Psychology

E-mail: geoffrey.patching@psy.lu.se

The Bayes Factor

The Bayes factor (BF) is the likelihood ratio of the evidences given the hypotheses

$$\frac{P(h_1 \mid d)}{P(h_o \mid d)} = \frac{P(d \mid h_1)}{P(d \mid h_o)} \times \frac{P(h_1)}{P(h_0)}$$

Posterior odds   Bayes Factor   Prior odds

-> quantifies the strength of evidence provided by the data

'Bayes factor' rise in psychology

Number of articles retrieved by searching for 'Bayes factor' (in text) in PsycINFO

Why use Bayes factor

Some reasons given in empirical research papers

"p-values are notoriously hard to interpret"

"A good alternative when having to work with small samples"

"To obtain the odds for or against the null hypothesis"

"To help interpret main results that did not reach an alpha of 0.05"

"Because our primary findings were not statistically significant"

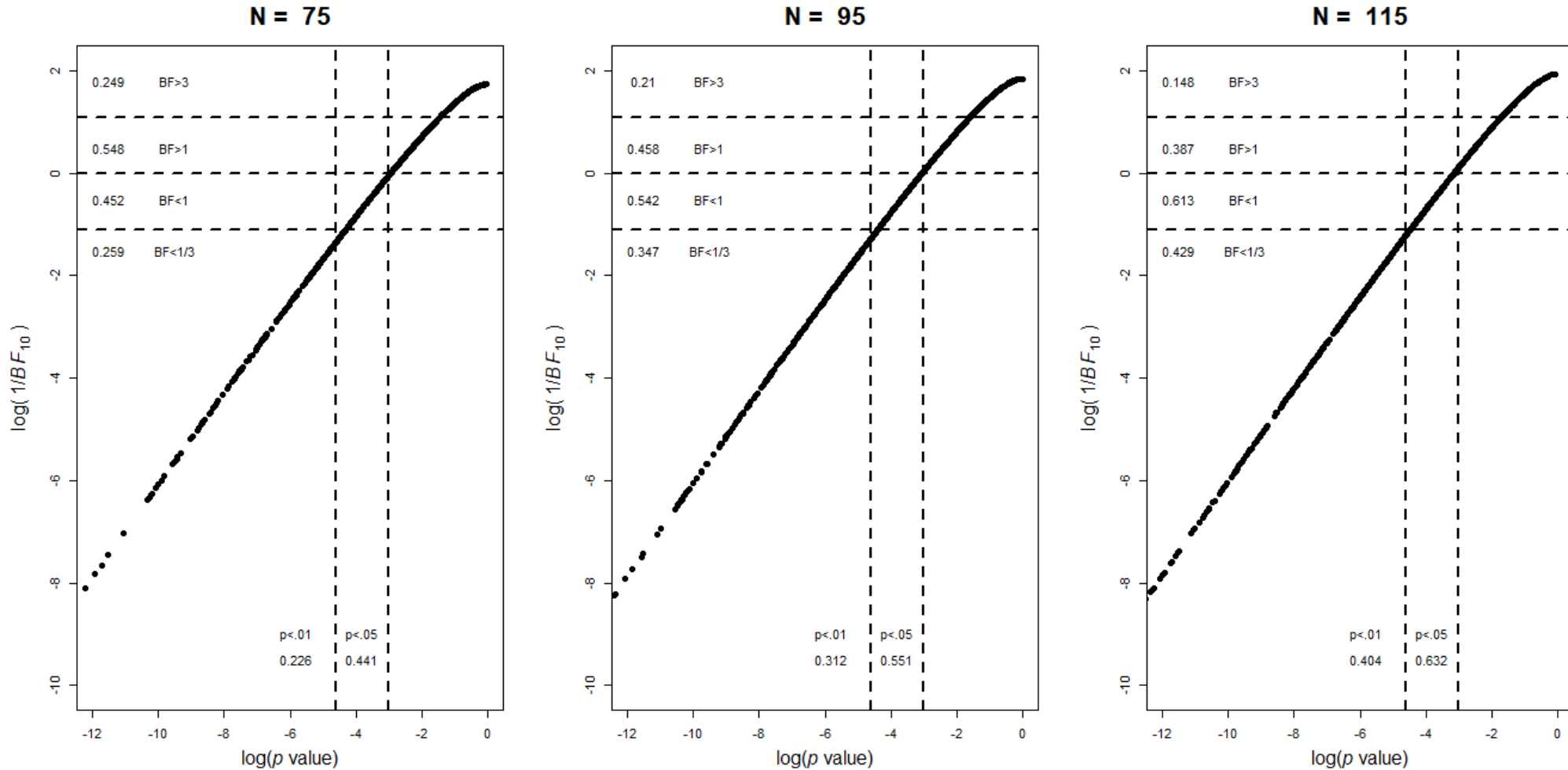# Interpretation of Bayes factors

Used to conclude the null-hypothesis is true

- sometimes even making it into the title of the article
  (e.g., *No relationship between x and y in healthy individuals*).

Sampling variability is often ignored or underestimated.

In short, people conduct experiments because they want to know about the truth or falsehood of their hypothesis.

# Relations between *BF*s and *p*-values
(Effect size = 0.3)

Each plot based on 1000 simulations, drawn from 2 independent samples ~ normal distribution

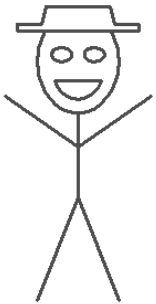Interpretation differs but close correspondence between Bayes Factors and *p* values

Relations between *BF*s and *p* values
(Effect size = 0)

Each plot based on 1000 simulations, drawn from 2 independent samples ~ normal distribution
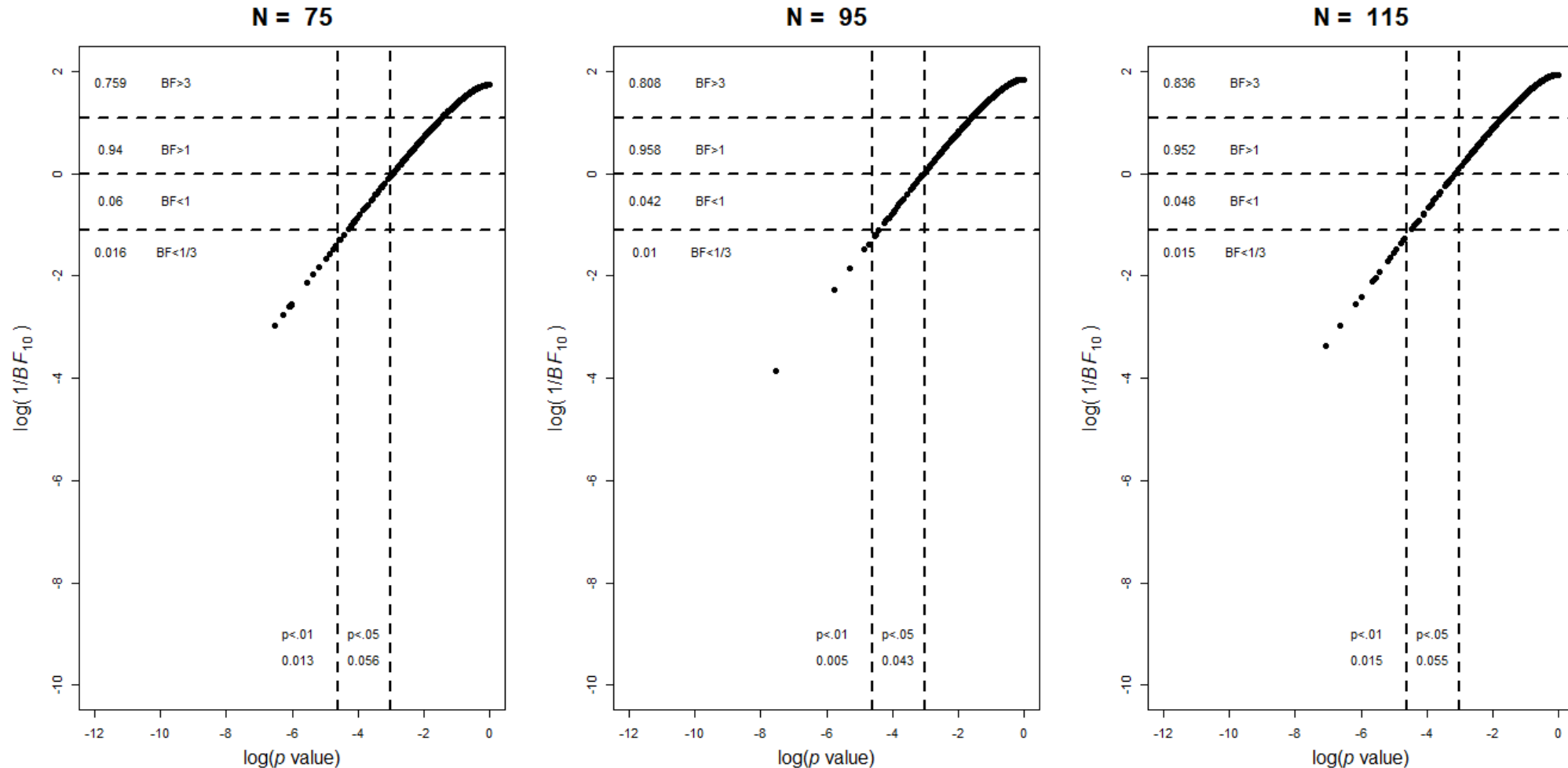
Interpretation differs but close correspondence between Bayes Factors and *p* values

Interpretation of p values / Bayes factors
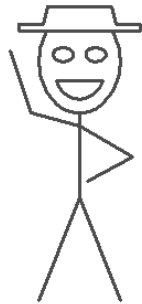
Geoff Cumming (2013) "Dance of the p values"

Dance of the Bayes Factors

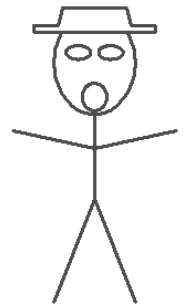|	Bayes Factor BF10	Label	
Bayes factor (BF_{10}) scale	** >10	Strong evidence for H1	Great pleasure, dancing drinking
	* 3-10	Moderate evidence for H1	Consolation prize. Fair publication
	? 1-3	Anecdotal evidence for H1	Frustration, if only
	? 1/3 - 1	Anecdotal evidence for H0	
	* 1/30 – 1/10	Moderate evidence for H0	Consolation prize. Fair publication
	** <1/10	Strong evidence for H0	Great pleasure, dancing drinking

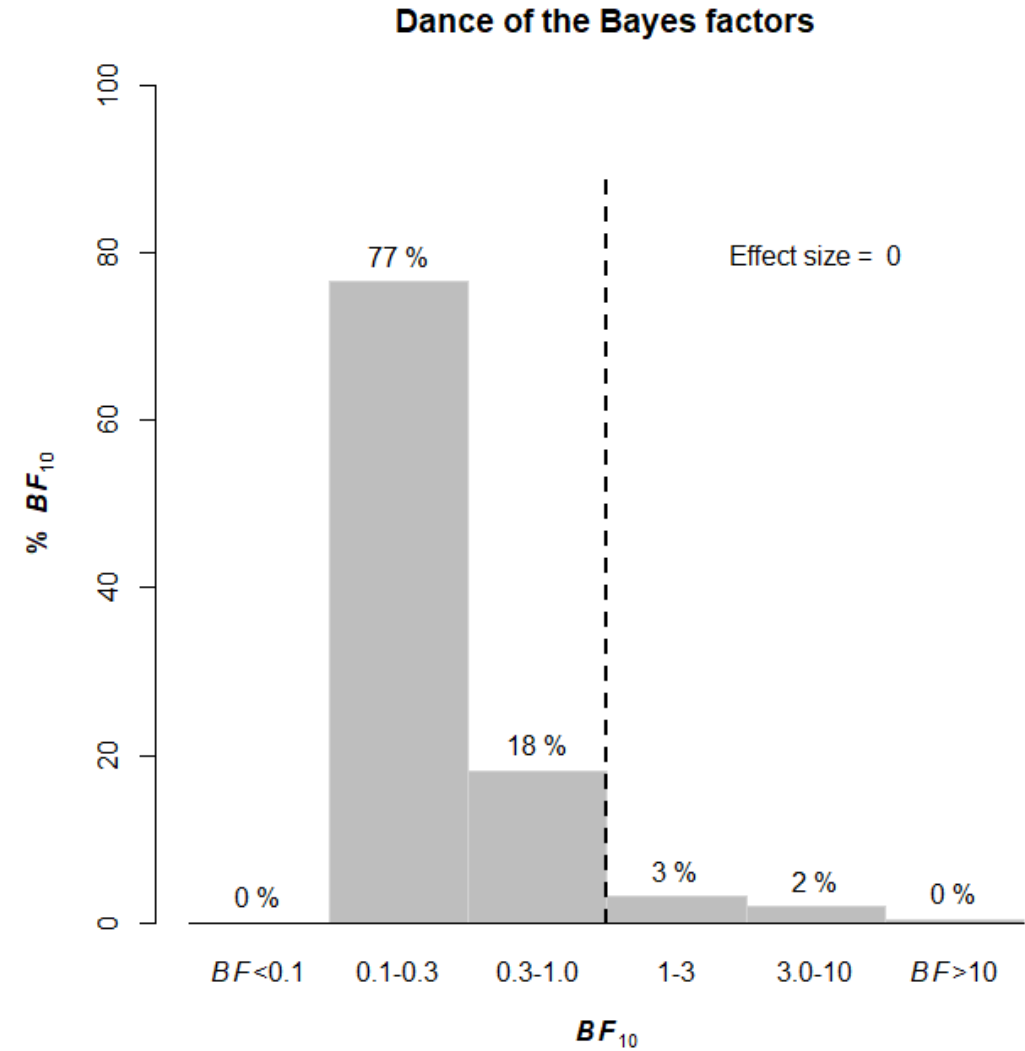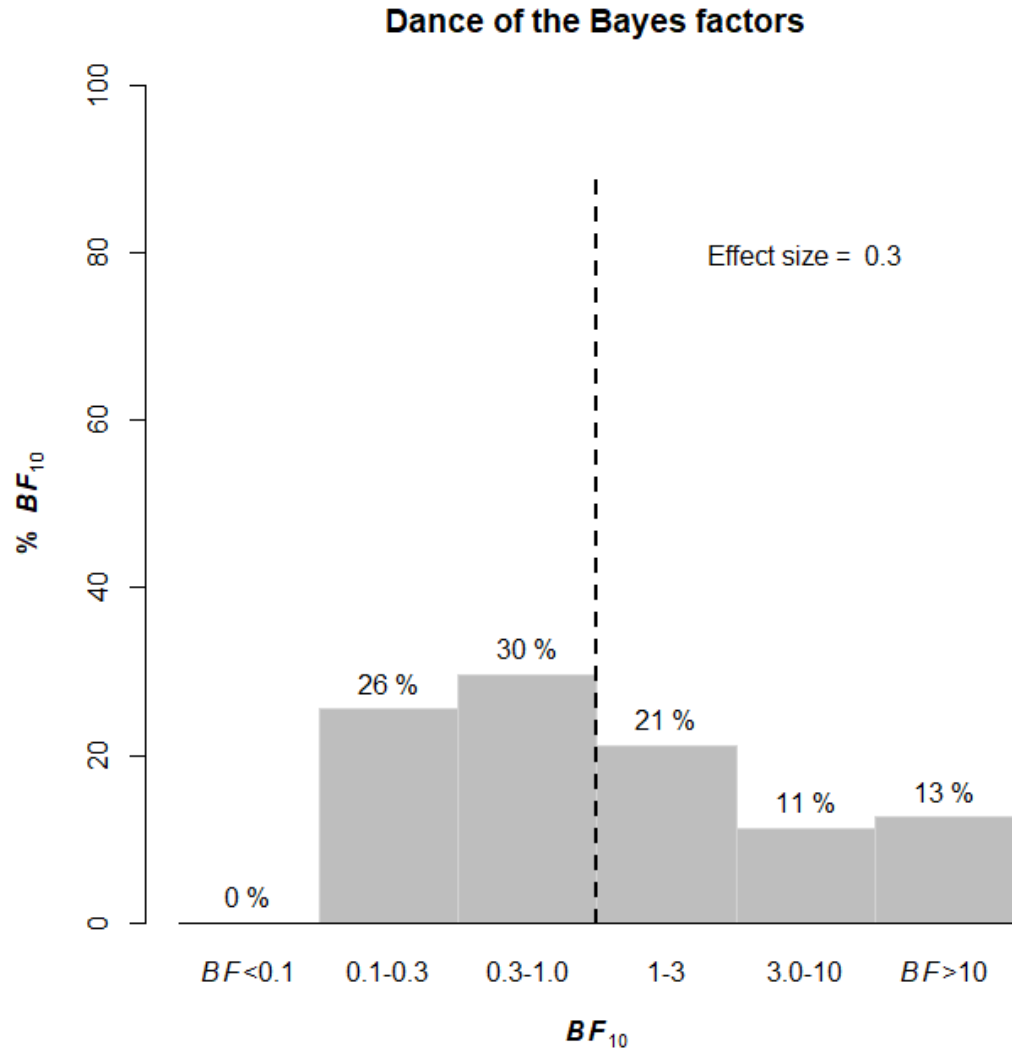| BF10 < 1/10	1/10> BF10 < 1/3	1/3 > BF10 < 3	3 > BF10 < 10	BF10 > 10
** Jump for joy	* happiness	Despair / depression	Annoyance	Surprise

https://xkcd.com/1478/

Dance of the Bayes factors

Each plot based on 1000 simulations, drawn from 2 independent samples of size $N = 75 \sim$ normal distribution

Dance of the Bayes factors

Dance of the Bayes factors

Bayesian parameter estimation

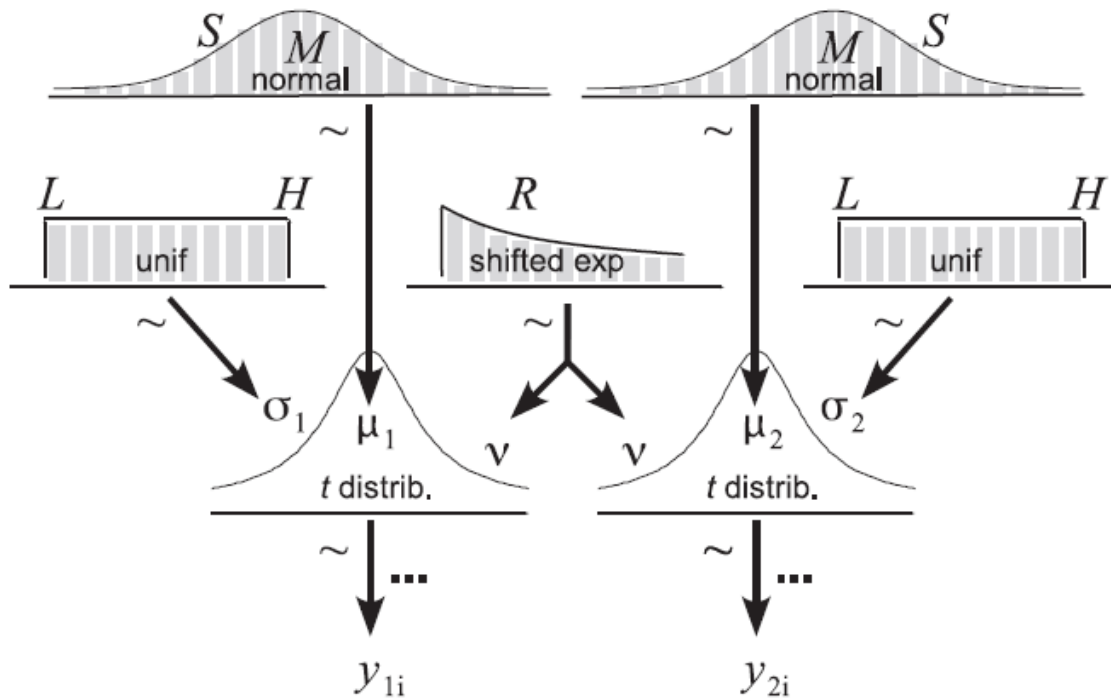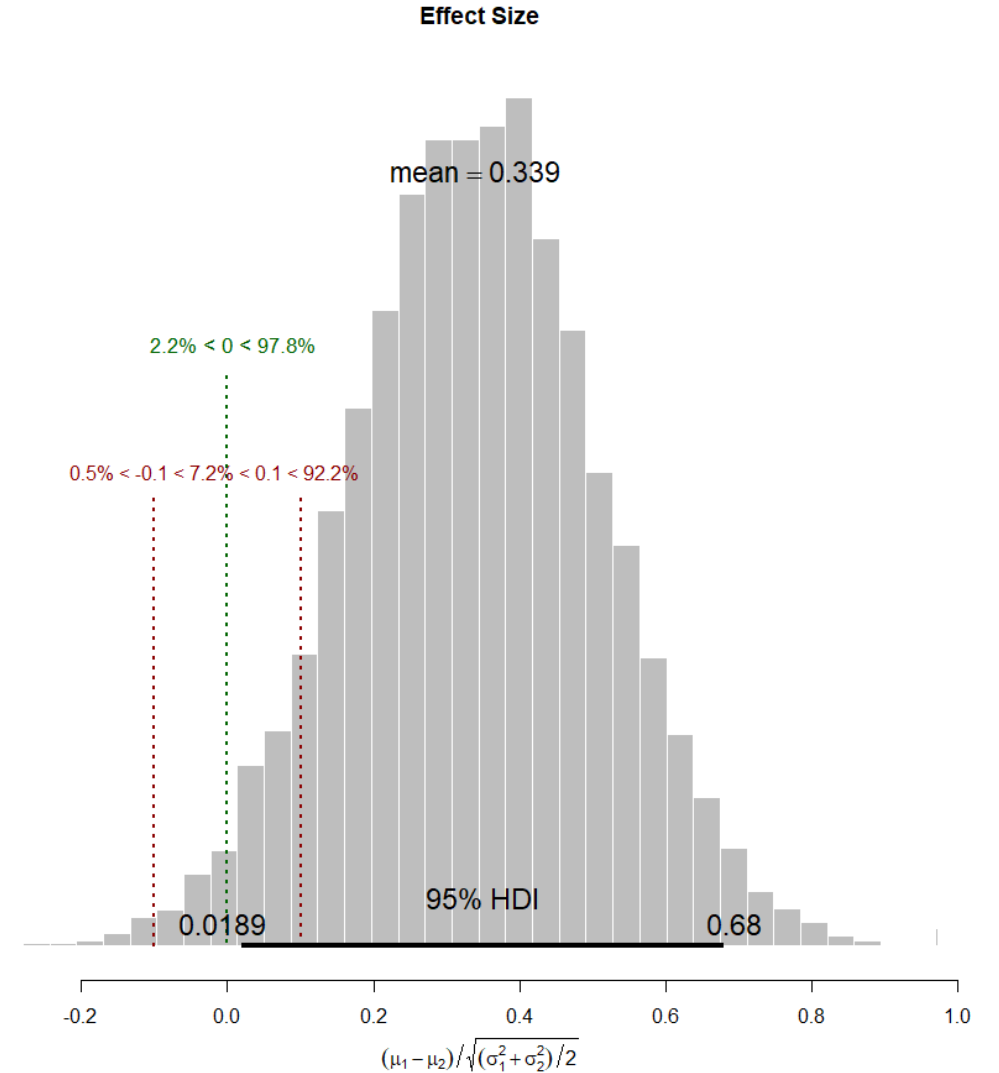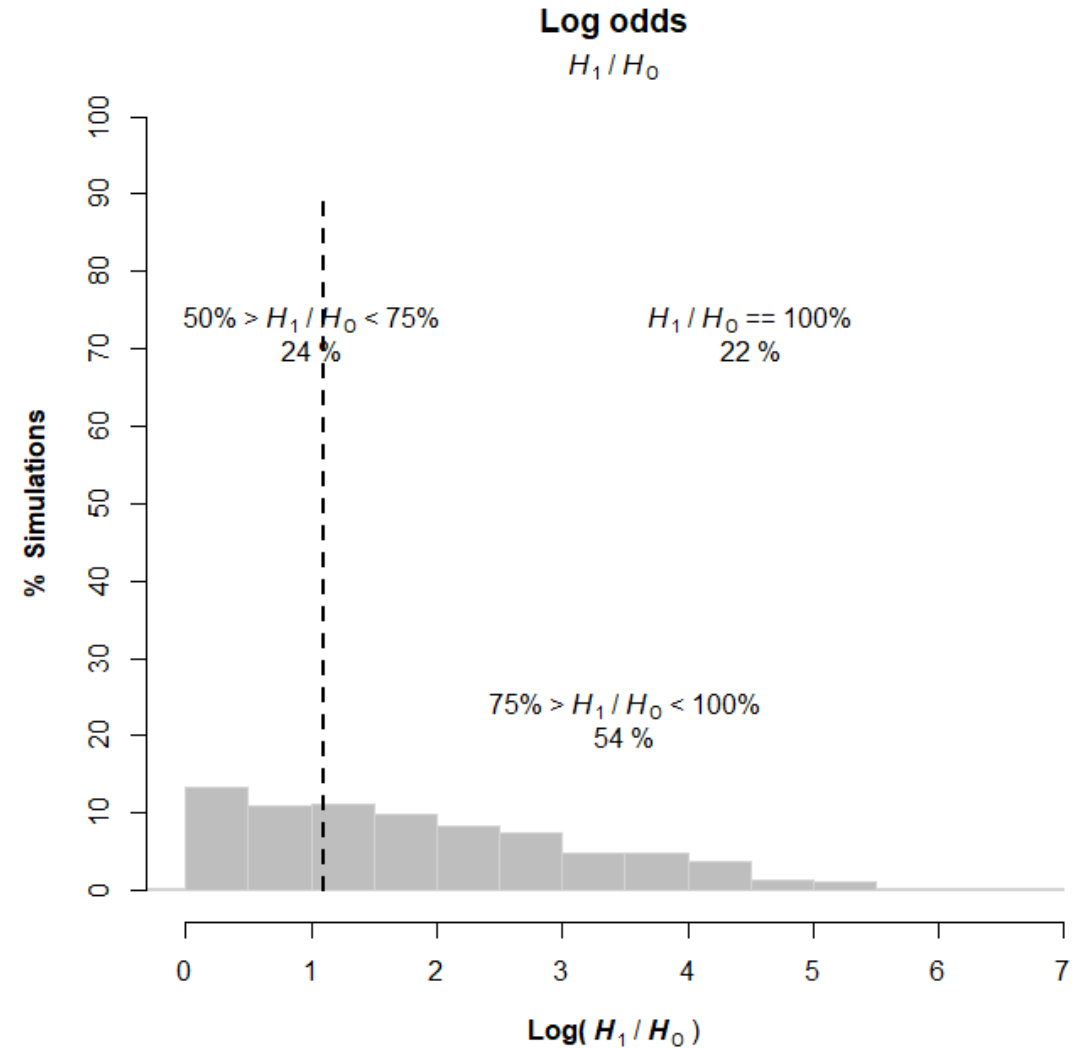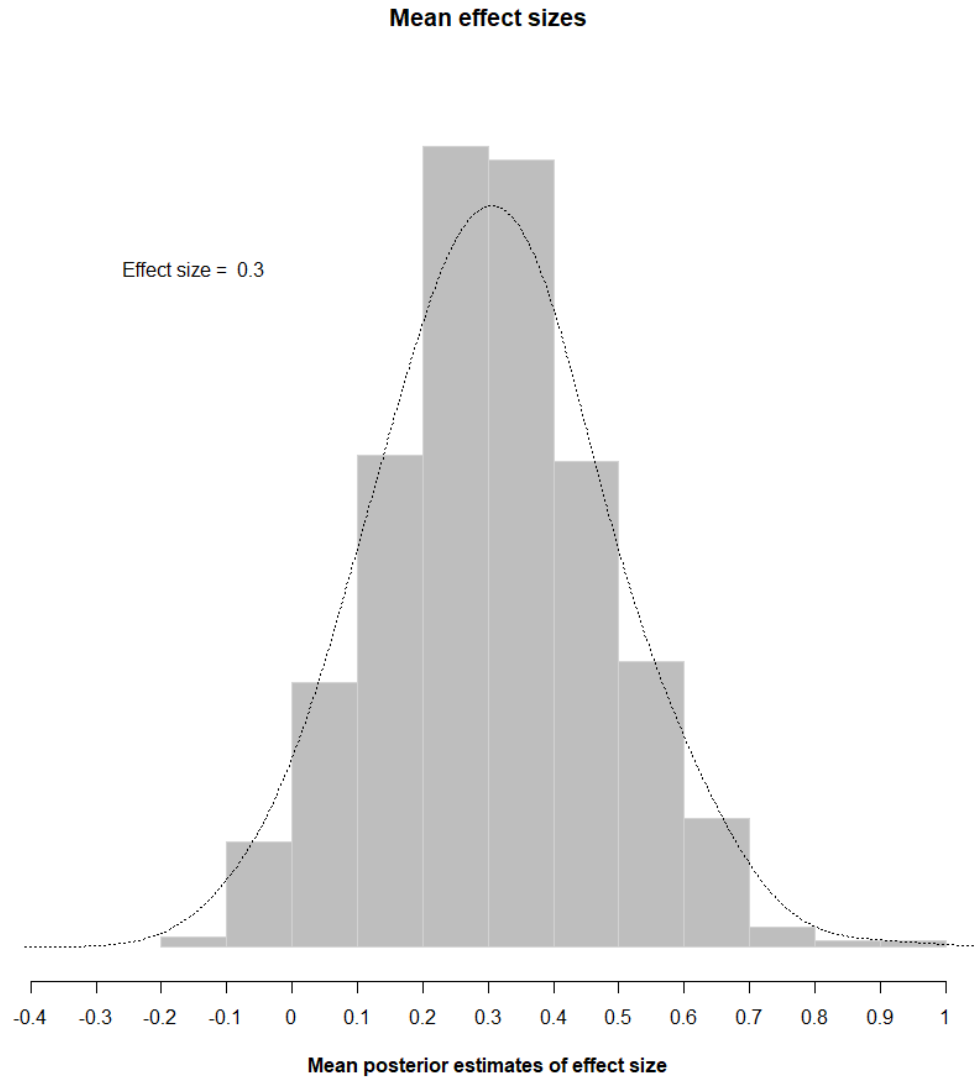J. K. Kruschke (2012). Bayesian estimation supersedes the t test.

Diagram of the model for Bayesian estimation
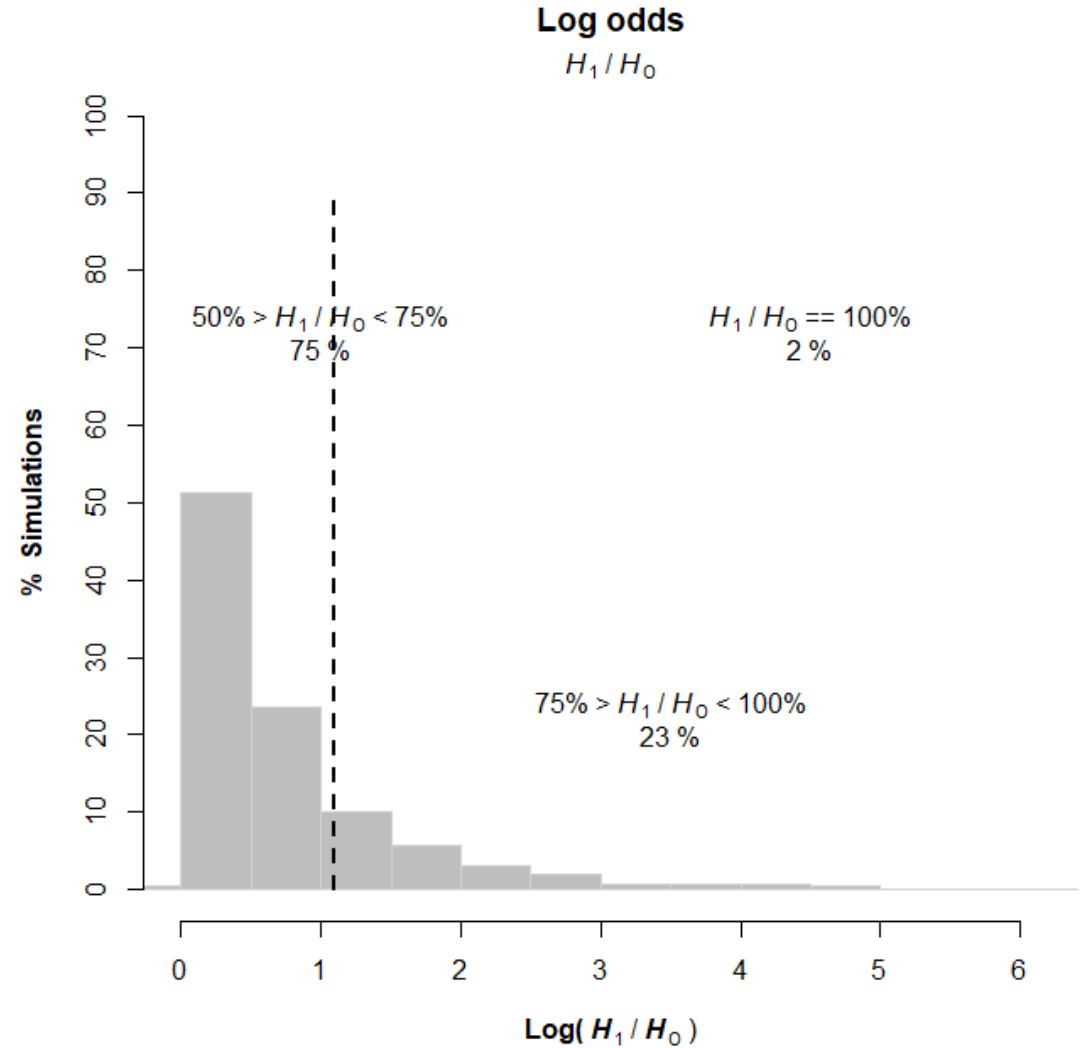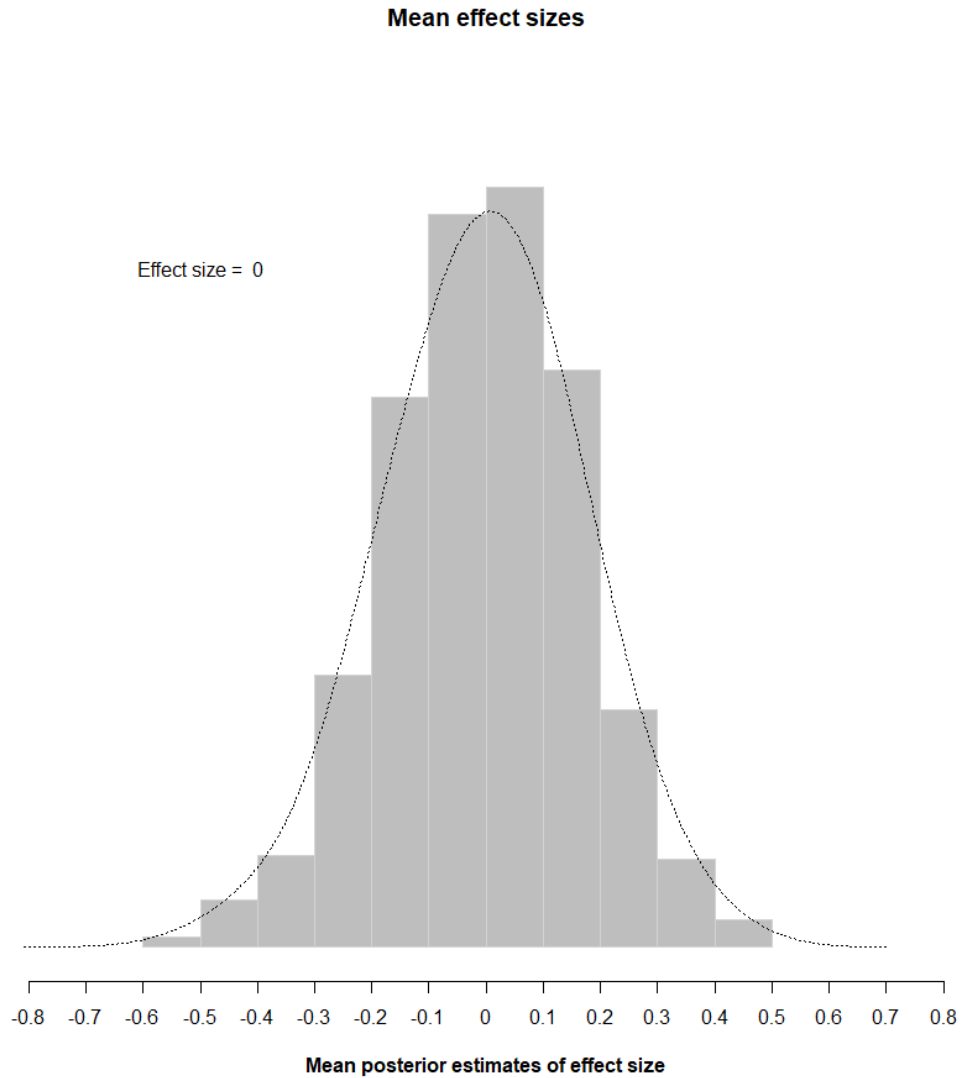(J. Kruschke, 2012, p. 3)

Bayesian parameter estimation

Each plot based on 1000 simulations, drawn from 2 independent samples of size $N = 75 \sim$ normal distribution

Bayesian parameter estimation

Each plot based on 1000 simulations, drawn from 2 independent samples of size $N = 75 \sim$ normal distribution

Take home message

Interpretation of the Bayes factor is dependent on the sensitivity of the design.

Yet, the Bayes factor alone indicates nothing about the magnitude of the effect or precision of the estimation.

Bayesian parameter estimation is more informative.

Although more taxing for students, parameter estimation should be encouraged in our teaching.