

# Bayesian data analysis using JASP

## Dani Navarro



[compcogscisydney.com/jasp-tute.html](http://compcogscisydney.com/jasp-tute.html)

## *Part 1: Theory*

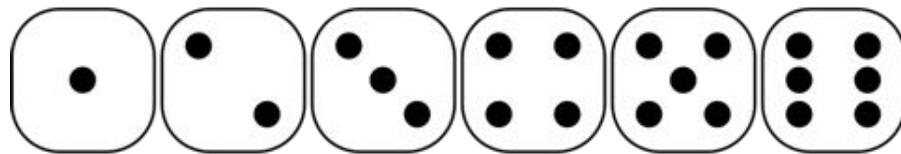
- Philosophy of probability
- Introducing Bayes rule
- Bayesian reasoning
- A simple example
- Bayesian hypothesis testing

## *Part 2: Practice*

- Introducing JASP
- Bayesian ANOVA
- Bayesian t-test
- Bayesian regression
- Bayesian contingency tables
- Bayesian binomial test

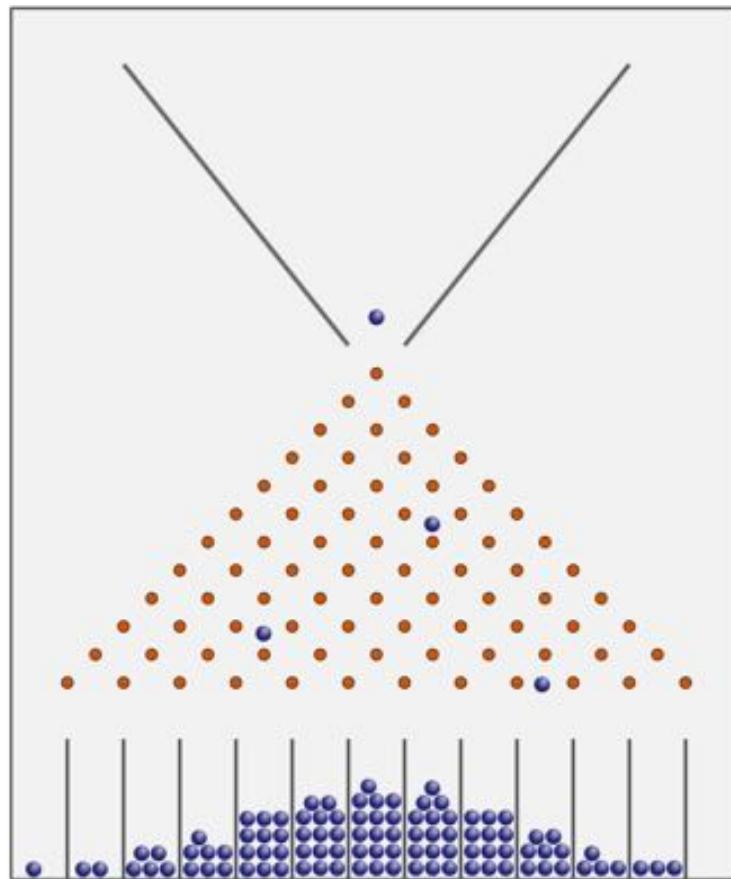
## 1.1 Philosophy of probability

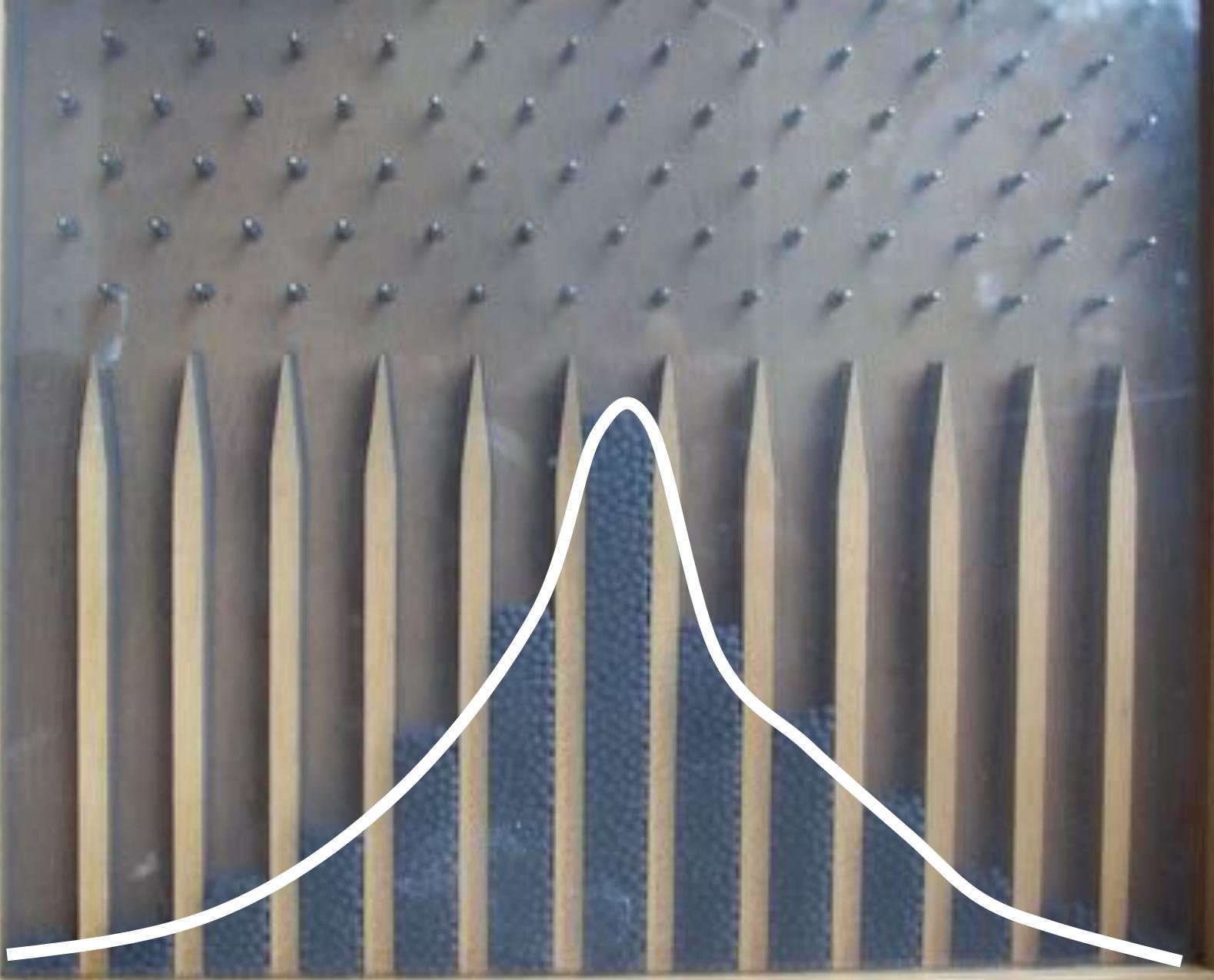
# Idea #1:“Aleatory” processes

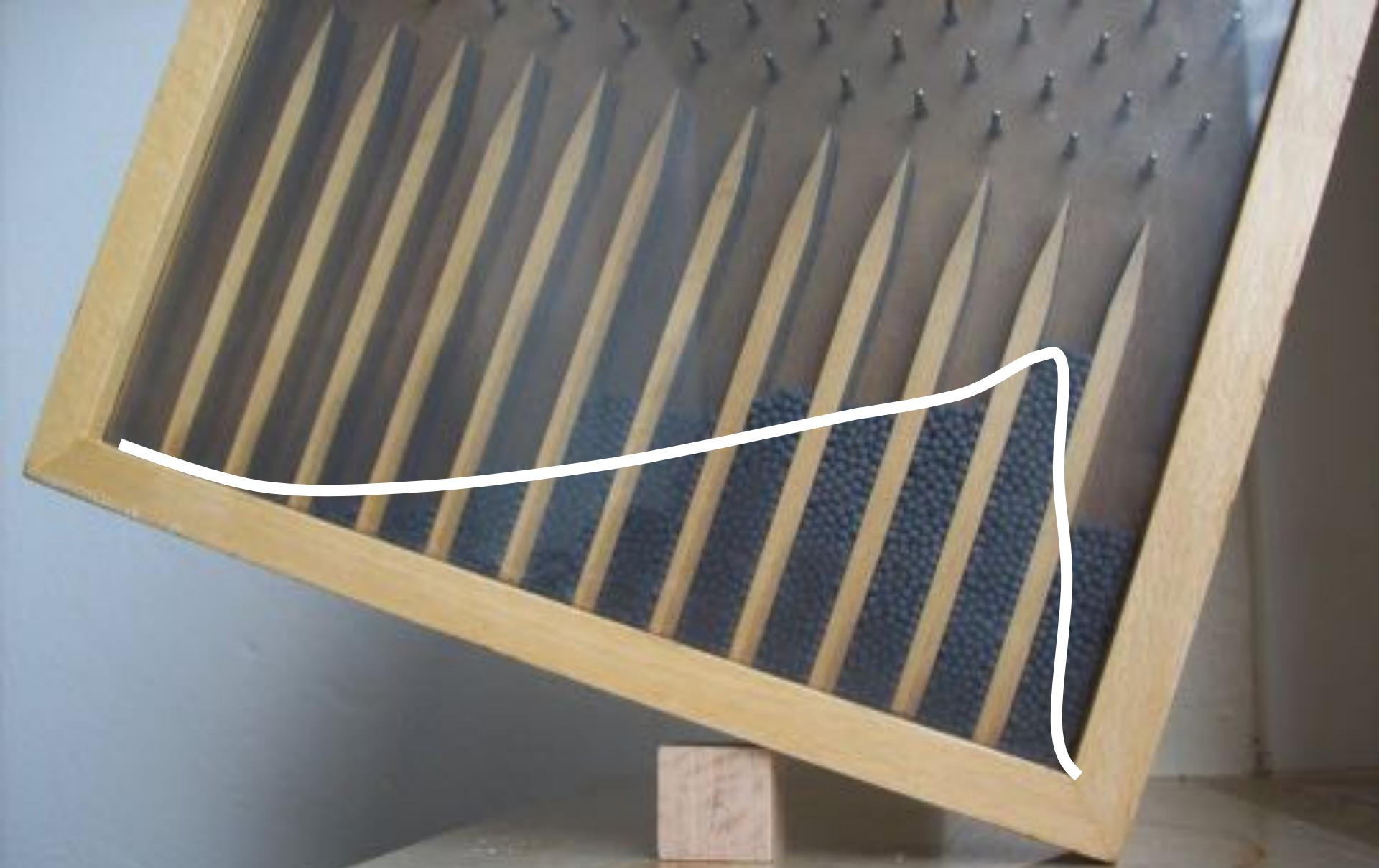


Probability is an objective characteristic associated with physical processes, defined by counting the relative frequencies of different kinds of events when that process is invoked

# “Aleatory” processes



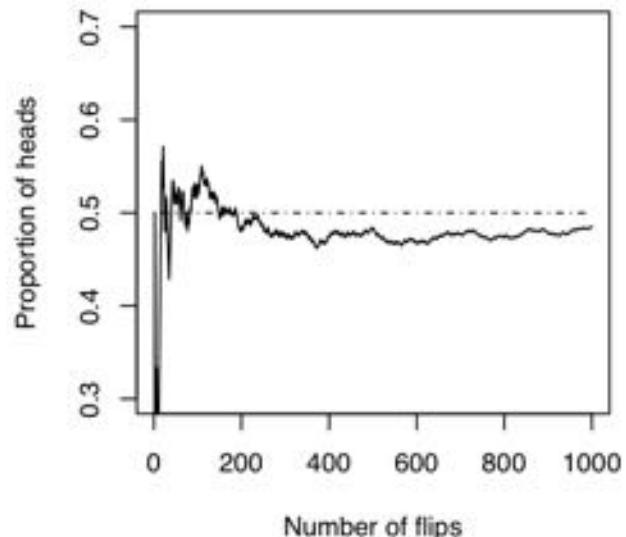




# Frequentist statistics

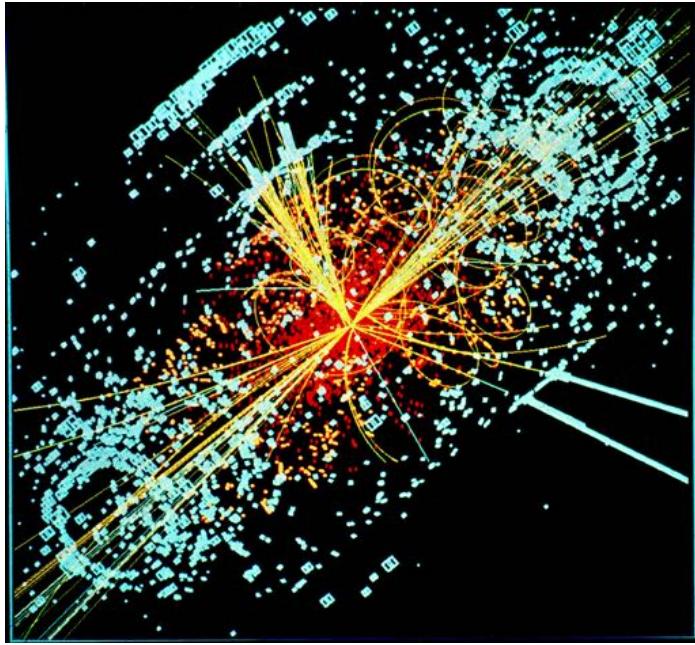


Coin flipping is an aleatory process, and can be repeated as many times as you like



The probability of a head is defined as the long-run frequency

# Frequentist statistics



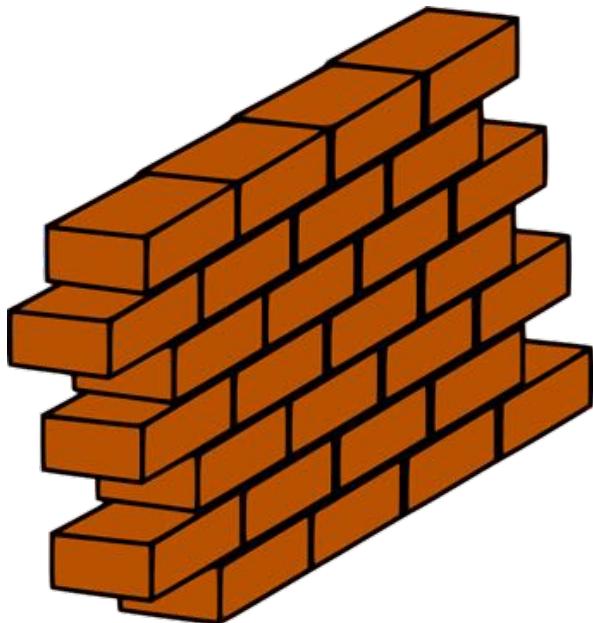
A particle physics experiment is a repeatable procedure, and thus a frequentist probability can be constructed to describe its outcomes

	mass →	charge →	spin →	
QUARKS				
u	$\approx 2.3 \text{ MeV}/c^2$	2/3	1/2	up
c	$\approx 1.275 \text{ GeV}/c^2$	2/3	1/2	charm
t	$\approx 173.07 \text{ GeV}/c^2$	2/3	1/2	top
g	0	0	1	gluon
Higgs boson	$\approx 126 \text{ GeV}/c^2$	0	0	H
GAUGE BOSONS				
d	$\approx 4.8 \text{ MeV}/c^2$	-1/3	1/2	down
s	$\approx 95 \text{ MeV}/c^2$	-1/3	1/2	strange
b	$\approx 4.18 \text{ GeV}/c^2$	-1/3	1/2	bottom
γ	0	0	1	photon
e	$0.511 \text{ MeV}/c^2$	-1	1/2	electron
μ	$105.7 \text{ MeV}/c^2$	-1	1/2	muon
τ	$1.777 \text{ GeV}/c^2$	-1	1/2	tau
Z	$91.2 \text{ GeV}/c^2$	0	1	Z boson
ν <sub>e</sub>	$<2.2 \text{ eV}/c^2$	0	1/2	electron neutrino
ν <sub>μ</sub>	$<0.17 \text{ MeV}/c^2$	0	1/2	muon neutrino
ν <sub>τ</sub>	$<15.5 \text{ MeV}/c^2$	0	1/2	tau neutrino
W	$80.4 \text{ GeV}/c^2$	±1	1	W boson

A scientific theory is not a repeatable procedure, and cannot be assigned a probability: there is no such thing as “the probability that my theory is true”

# Idea #2: “Epistemic” uncertainty

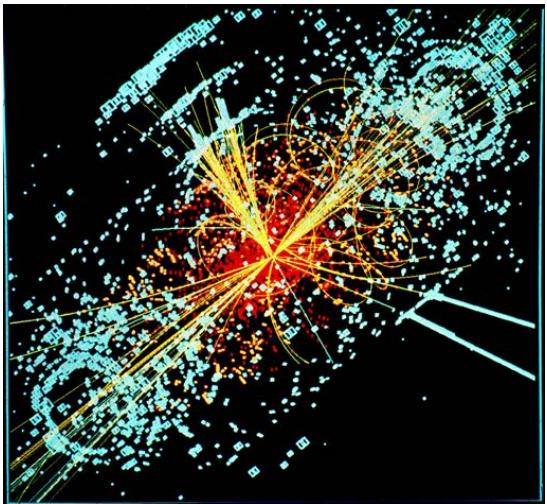
Probability is an subjective characteristic associated with rational agents, defined by assessing the strength of belief that the agent holds in different propositions



?



# “Bayesian” statistics



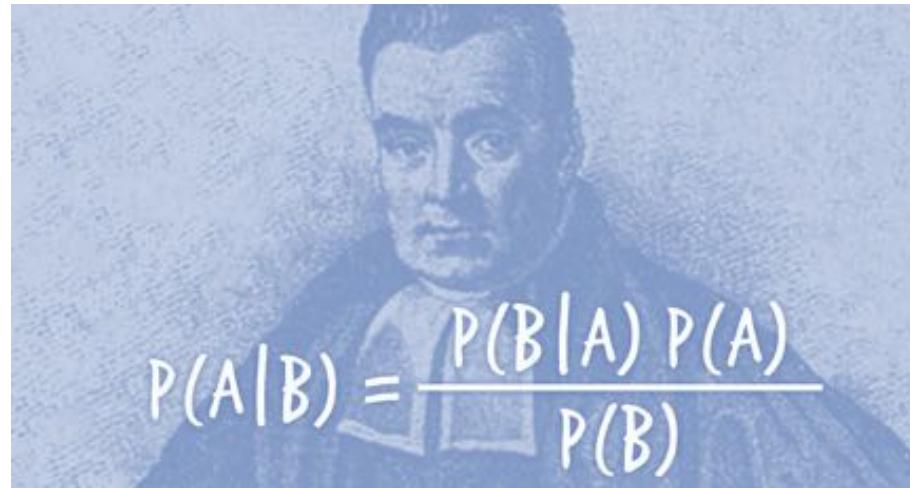
Probabilities can be attached to any proposition that an agent can believe

A particle physics experiment generates observable events about which a rational agent might hold beliefs

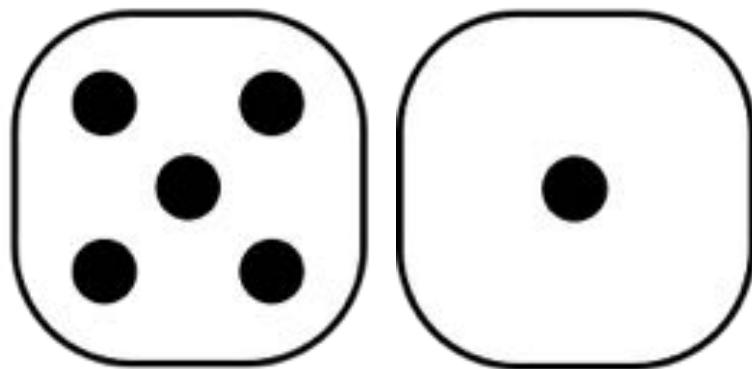
QUARKS		GAUGE BOSONS	
mass → $\approx 2.3 \text{ MeV}/c^2$	charge → $2/3$	mass → $\approx 1.275 \text{ GeV}/c^2$	mass → $\approx 126 \text{ GeV}/c^2$
spin → $1/2$	up	spin → $1/2$	Higgs boson
	c		
	t		
mass → $\approx 4.8 \text{ MeV}/c^2$	charge → $-1/3$	mass → $\approx 95 \text{ MeV}/c^2$	mass → $\approx 0 \text{ GeV}/c^2$
spin → $1/2$	down	spin → $1/2$	gluon
	s		
	b		
mass → $\approx 0.511 \text{ MeV}/c^2$	charge → $-1$	mass → $\approx 105.7 \text{ MeV}/c^2$	mass → $\approx 0 \text{ GeV}/c^2$
spin → $1/2$	electron	spin → $1/2$	Z boson
	$\mu$		
	$\tau$		
mass → $\approx 0 \text{ eV}/c^2$	charge → $0$	mass → $\approx 0 \text{ MeV}/c^2$	mass → $\approx 91.2 \text{ GeV}/c^2$
spin → $1/2$	$\nu_e$	spin → $1/2$	W boson
	$\nu_\mu$		
	$\nu_\tau$		

A scientific theory contains a set of propositions about which a rational agent might hold beliefs

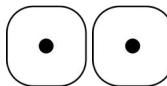
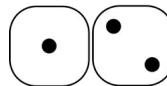
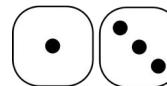
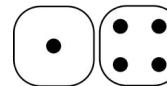
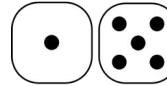
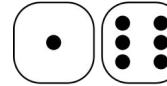
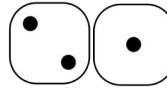
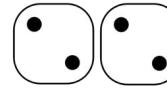
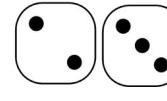
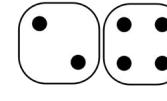
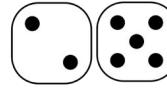
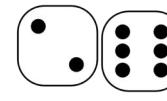
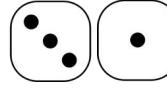
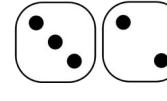
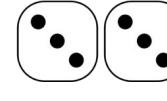
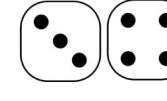
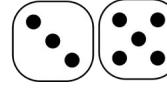
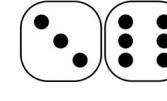
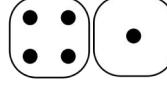
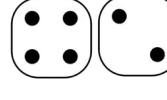
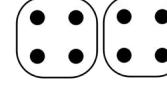
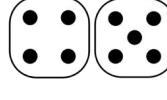
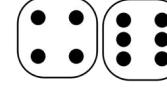
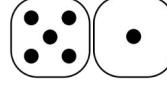
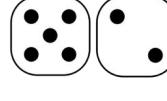
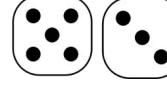
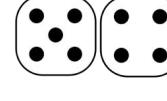
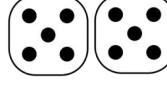
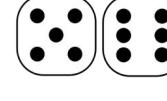
## I.2 Introducing Bayes rule



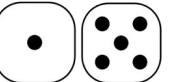
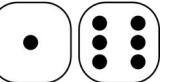
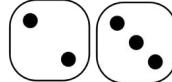
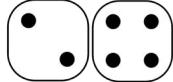
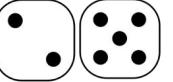
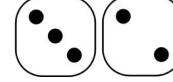
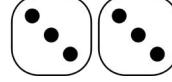
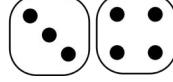
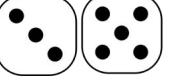
**Roll two dice...**



## Thirty six possible cases

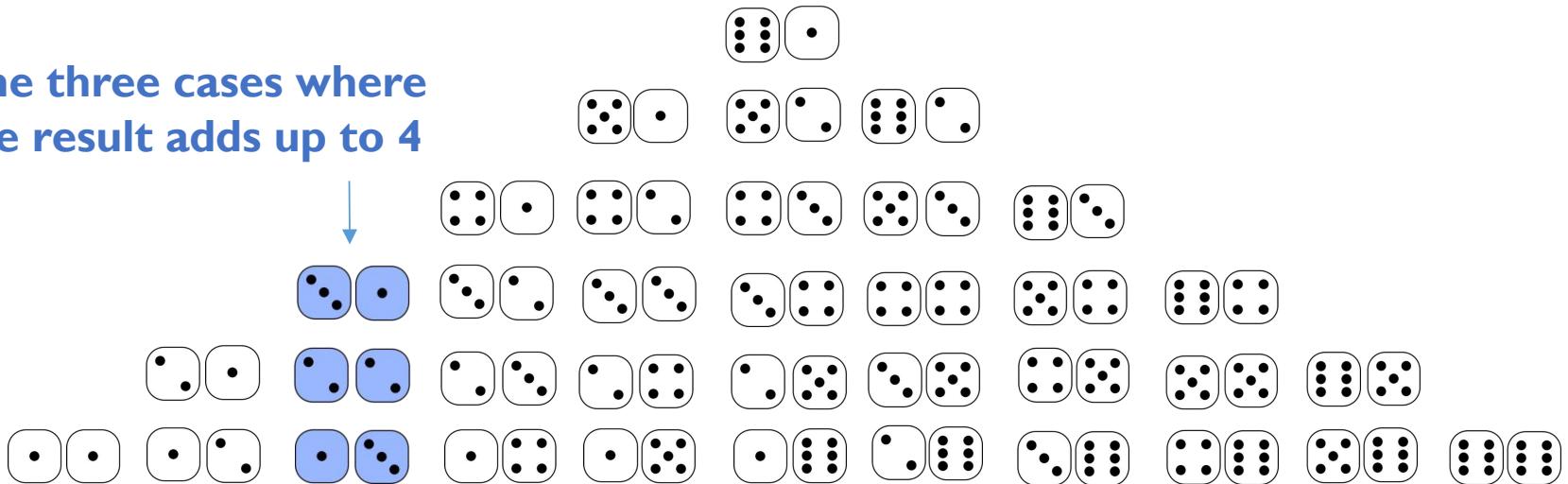
					
					
					
					
					
					

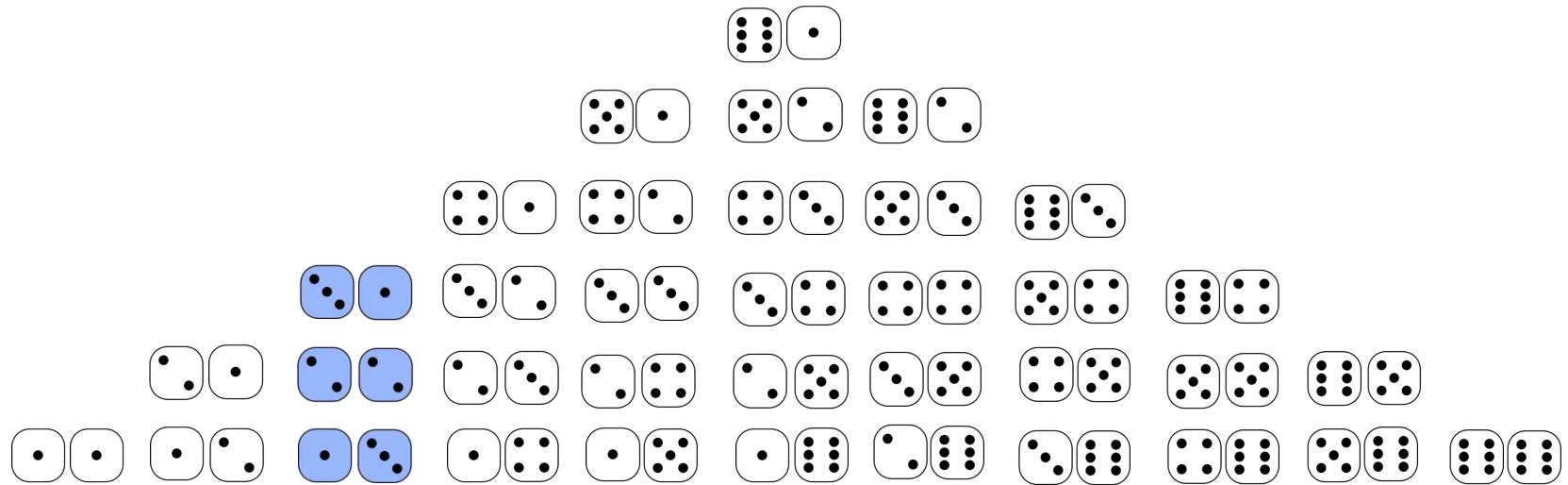
## Three cases where the dice add up to 4

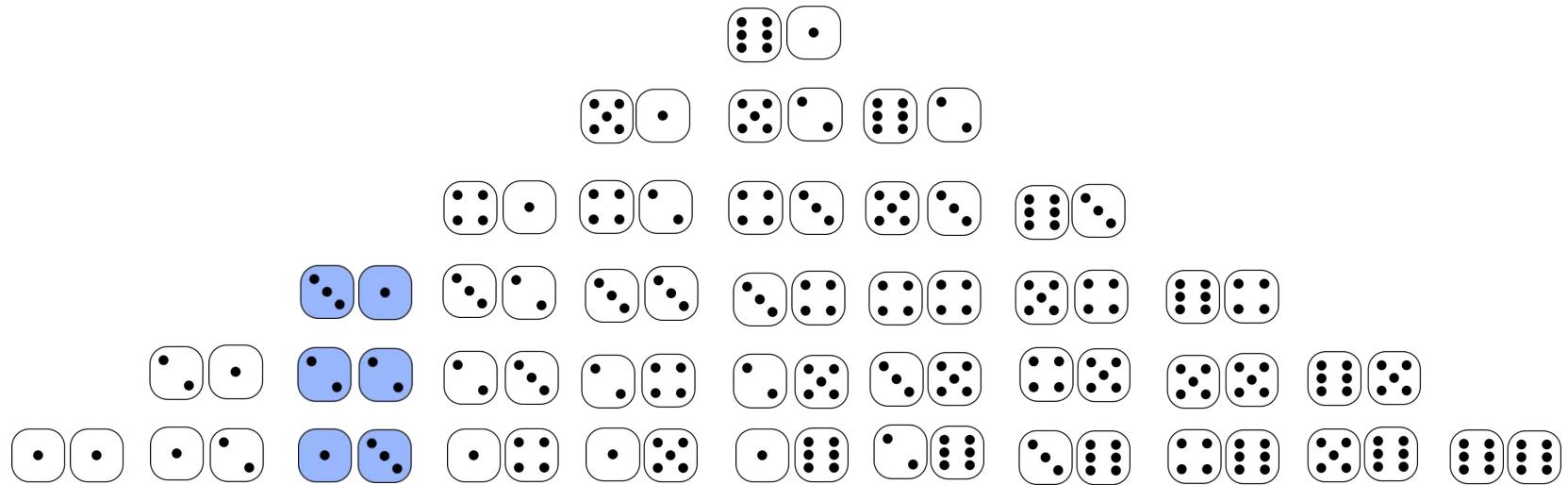
## All 36 cases organised by outcome

The three cases where  
the result adds up to 4





Roll	2	3	4	5	6	7	8	9	10	11	12
N	1	2	3	4	5	6	5	4	3	2	1

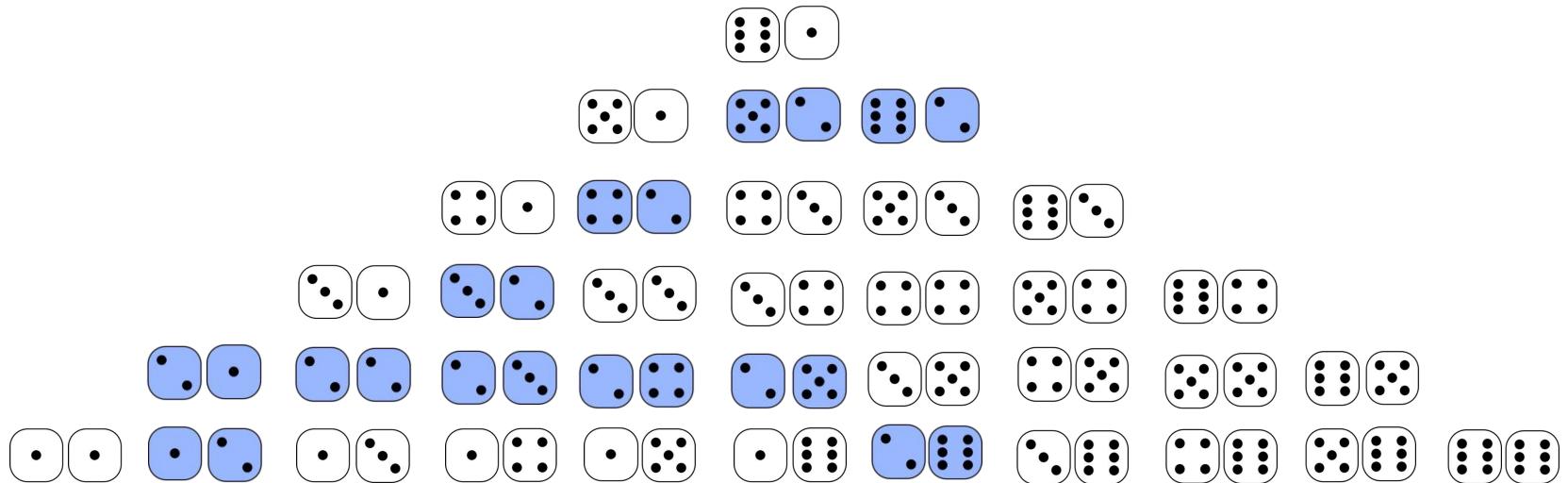


Roll	2	3	4	5	6	7	8	9	10	11	12
N	1	2	3	4	5	6	5	4	3	2	1
Prob	.028	.056	.083	.111	.139	.167	.139	.111	.083	.056	.028



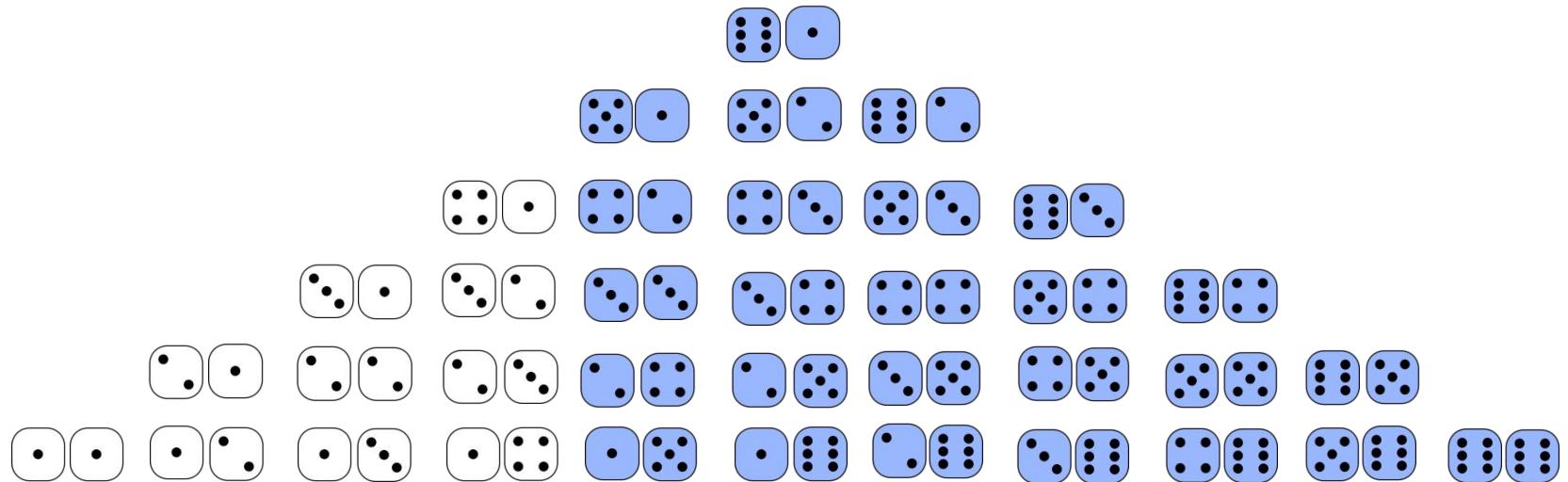
Probability = 3/36 = .083

# A: “at least one die has a value of 2”



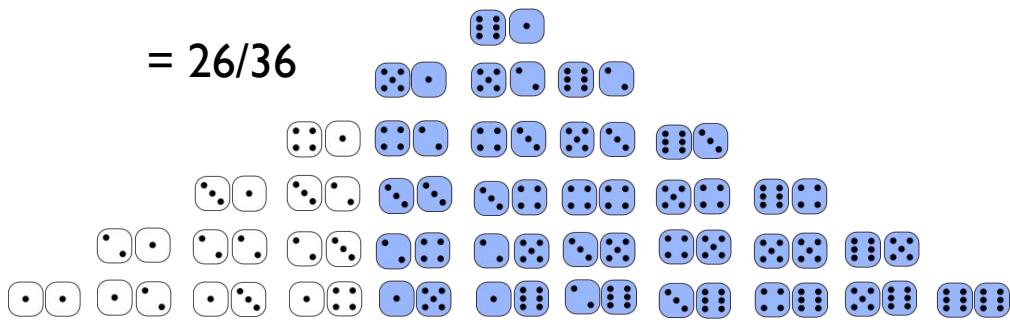
$$P(A) = \frac{11}{36} = .31$$

## B: “the total is at least six”



$$P(B) = \frac{26}{36} = .72$$

$$= 26/36$$

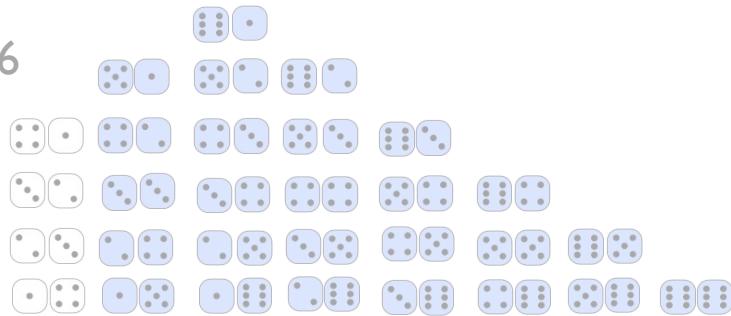


Probability that the total is at least 6



$$P(B)$$

$$= 26/36$$

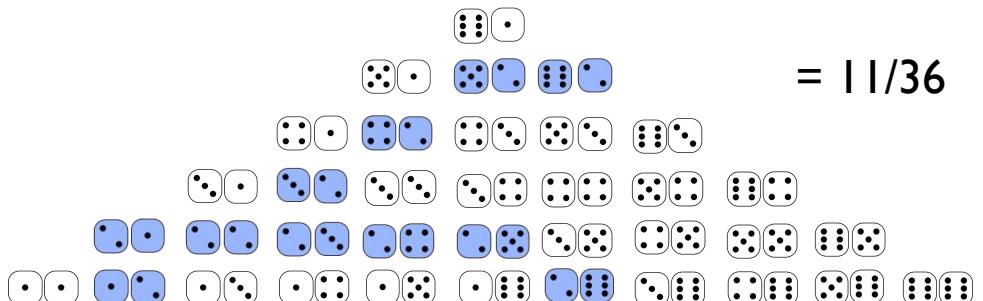


Probability that the total is at least 6

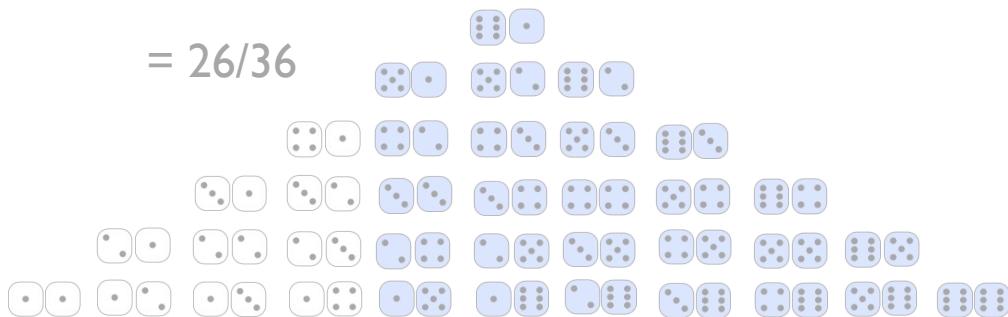
$$P(B)$$

$$P(A)$$

Probability that at least one die has a 2



$$= 26/36$$



Probability that the total is at least 6

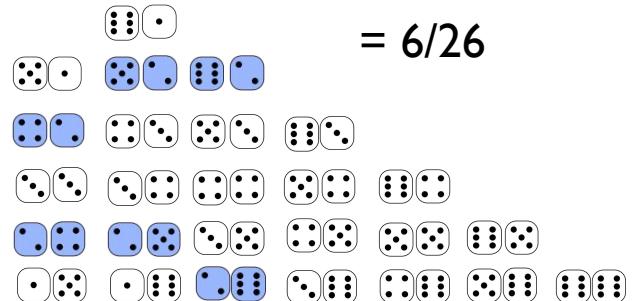
$$P(B)$$

$$P(A|B)$$

$$P(A)$$

Probability that at least one die has a 2

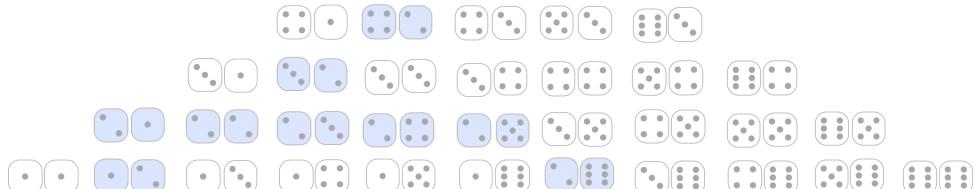
$$= 6/26$$



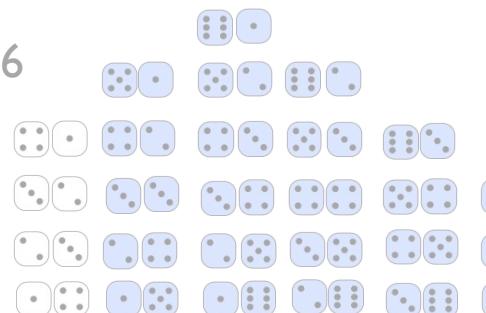
Probability that at least one die has a 2 **given** that the total is at least 6



$$= 11/36$$



$$= 26/36$$



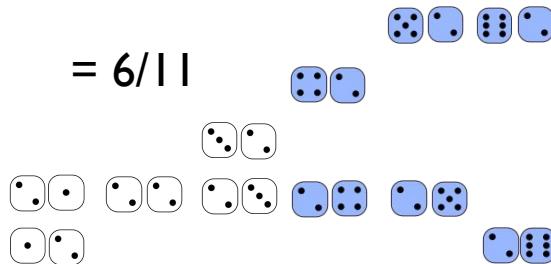
Probability that the total is at least 6

$$P(B|A)$$

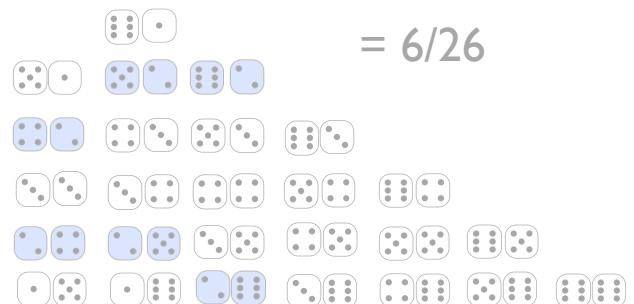


Probability that the total is at least 6  
**given** that at least one die has a 2

$$= 6/11$$



$$= 6/26$$



Probability that at least one die has a 2 given that the total is at least 6

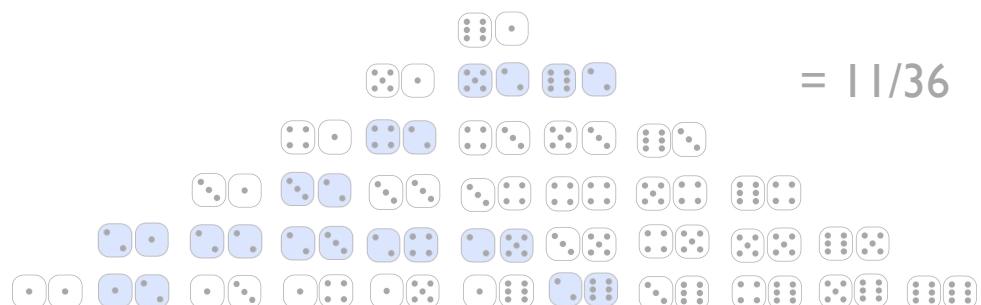
$$P(B)$$

$$P(A|B)$$

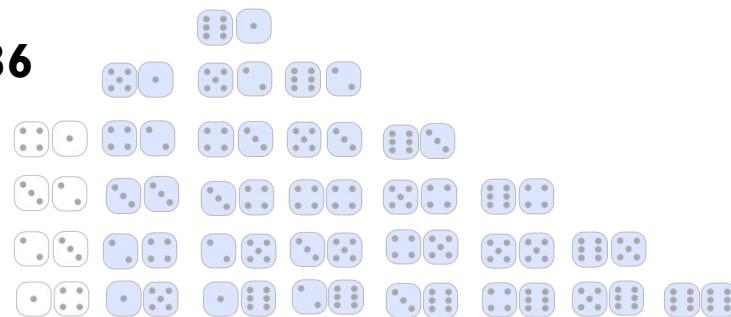
$$P(A)$$



Probability that at least one die has a 2



= 26/36

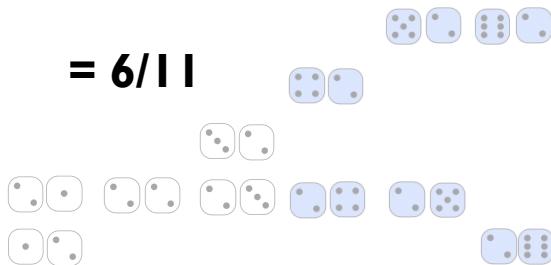


Probability that the total is at least 6

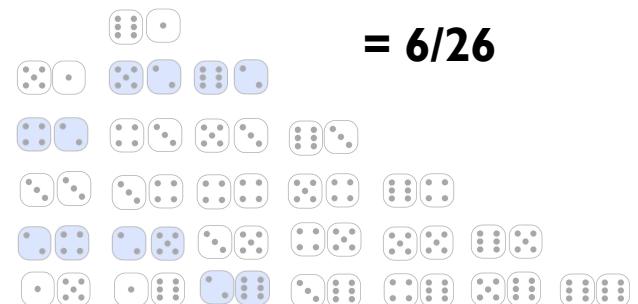
$$P(B|A) = \frac{P(B) \times P(A|B)}{P(A)}$$

Probability that the total is at least 6  
given that at least one die has a 2

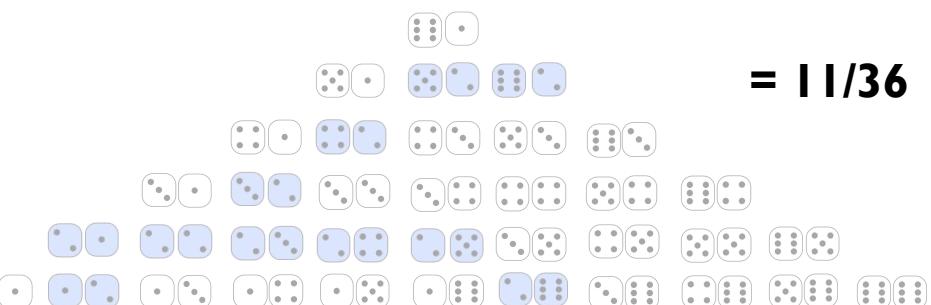
= 6/11



= 6/26



Probability that at least one die has a 2 given that the total is at least 6



# Let's check that:

$$P(A|B)$$



$$\frac{26}{36} \times \frac{6}{26} \div \frac{11}{36}$$

$$P(B)$$

$$P(A)$$

# Let's check that:

$$P(A|B)$$

$$P(B|A)$$



$$\frac{26}{36} \times \frac{6}{26} \div \frac{11}{36} = \frac{\cancel{26}}{\cancel{36}} \times \frac{6}{\cancel{26}} \times \frac{\cancel{36}}{11} = \frac{6}{11}$$

$$P(B)$$

$$P(A)$$



## I.3 Bayesian reasoning

**Bayes' rule** is a mathematical fact  
that probabilities must obey

$$P(B|A) = \frac{P(B) \times P(A|B)}{P(A)}$$

The equation  $P(B|A) = \frac{P(B) \times P(A|B)}{P(A)}$  is displayed. Four blue arrows point from the surrounding text to specific terms in the equation: an arrow points from "26/36" to the term  $P(B)$ ; another arrow points from "6/26" to the term  $P(A|B)$ ; a third arrow points from "6/11" to the term  $P(A)$ ; and a fourth arrow points from "11/36" to the denominator  $P(A)$ .

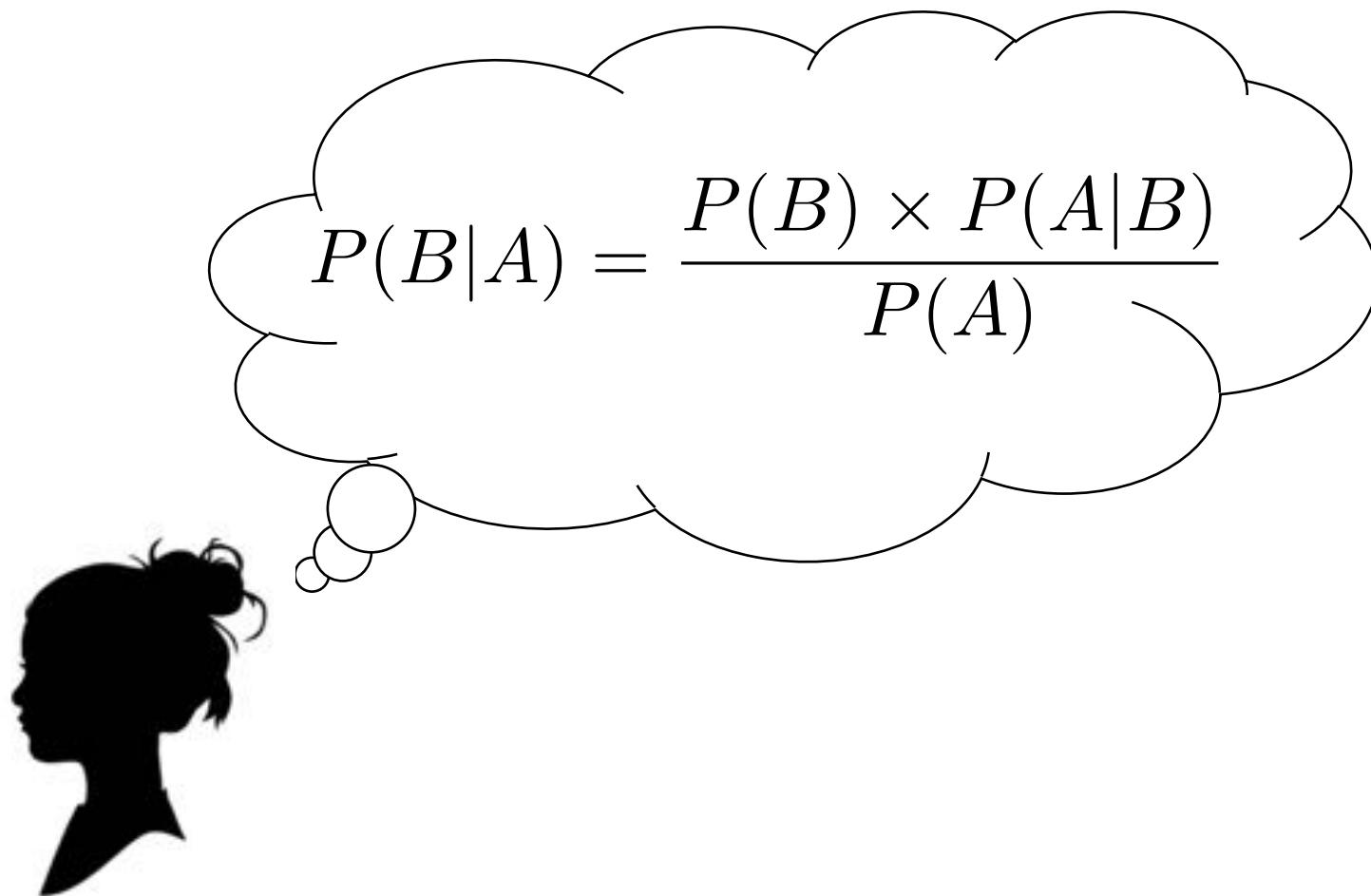
26/36

6/26

6/11

11/36

**Bayesian reasoning** happens when we combine this mathematical rule with epistemic probability

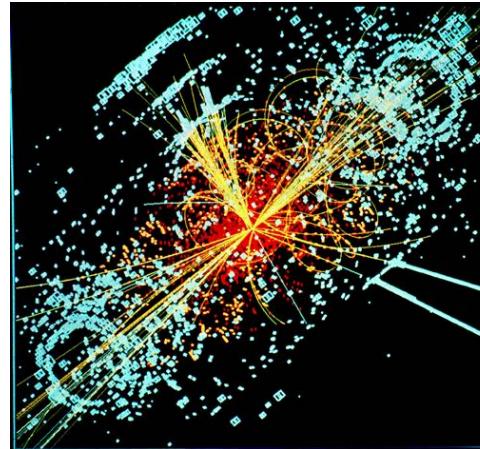


# For example...

mass →	$\approx 2.3 \text{ MeV}/c^2$	$\approx 1.275 \text{ GeV}/c^2$	$\approx 173.07 \text{ GeV}/c^2$	0	$\approx 126 \text{ GeV}/c^2$
charge →	2/3	2/3	2/3	0	0
spin →	1/2	1/2	1/2	1	0
up	u	c	t	g	H
charm					Higgs boson
top					
gluon					
down	d	s	b	γ	
strange					photon
bottom					
electron	e	μ	τ	Z	
muon					Z boson
tau					
electron neutrino	ν <sub>e</sub>	ν <sub>μ</sub>	ν <sub>τ</sub>	W	
muon neutrino					W boson
tau neutrino					

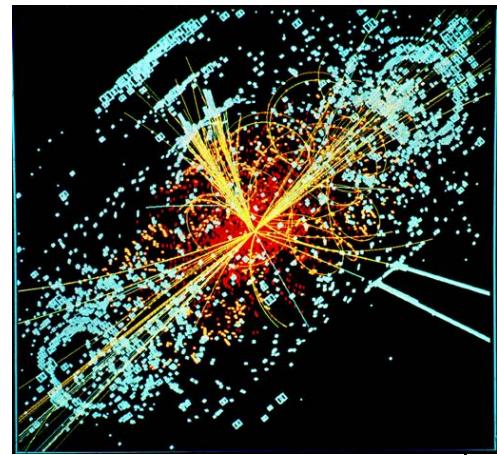
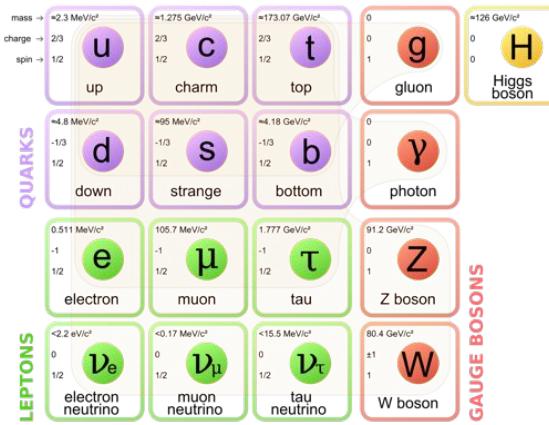
$h = A$  hypothesis about the world

$d =$  Some observable data



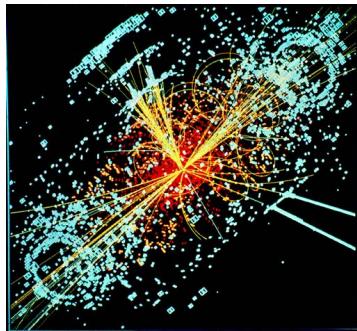
How strongly should I believe  
in this hypothesis...

... given that I have  
observed these data?



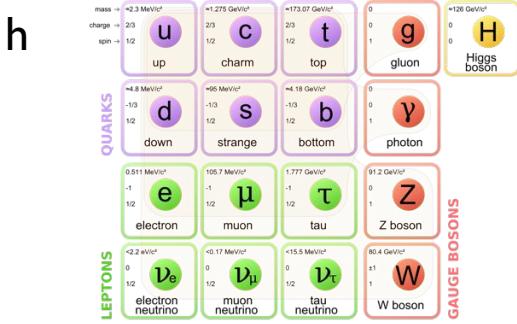
$h|d$

QUARKS	
mass $\sim <2.3 \text{ MeV}/c^2$	charge $\sim 2/3$
spin $\sim 1/2$	up
mass $\sim 1.275 \text{ GeV}/c^2$	charge $\sim 2/3$
spin $\sim 1/2$	c
mass $\sim 173.07 \text{ GeV}/c^2$	charge $\sim 2/3$
spin $\sim 1/2$	t
mass $\sim 1.18 \text{ GeV}/c^2$	charge $\sim 0$
spin $\sim 1/2$	gluon
mass $\sim 126 \text{ GeV}/c^2$	charge $\sim 0$
	Higgs boson
LEPTONS	
mass $\sim <4.8 \text{ MeV}/c^2$	charge $\sim -1/3$
spin $\sim 1/2$	d
mass $\sim 105.7 \text{ MeV}/c^2$	charge $\sim -1$
spin $\sim 1/2$	s
mass $\sim 177.7 \text{ GeV}/c^2$	charge $\sim -1$
spin $\sim 1/2$	b
mass $\sim 91.2 \text{ GeV}/c^2$	charge $\sim 0$
spin $\sim 1/2$	$\gamma$
mass $\sim 0.511 \text{ MeV}/c^2$	charge $\sim -1$
spin $\sim 1/2$	e
mass $\sim 105.7 \text{ MeV}/c^2$	charge $\sim -1$
spin $\sim 1/2$	$\mu$
mass $\sim 177.7 \text{ GeV}/c^2$	charge $\sim -1$
spin $\sim 1/2$	$\tau$
mass $\sim <0.17 \text{ MeV}/c^2$	charge $\sim 0$
spin $\sim 1/2$	$\nu_e$
mass $\sim <15.5 \text{ MeV}/c^2$	charge $\sim 0$
spin $\sim 1/2$	$\nu_\mu$
mass $\sim 80.4 \text{ GeV}/c^2$	charge $\sim \pm 1$
spin $\sim 1/2$	$\nu_\tau$
mass $\sim <2.2 \text{ eV}/c^2$	charge $\sim 0$
spin $\sim 1/2$	W boson
GAUGE BOSONS	



The posterior probability that my hypothesis is true given that I have observed these data...

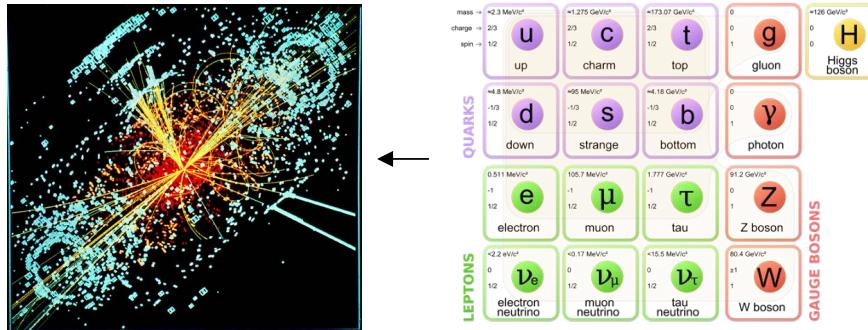
$$P(h|d) = \frac{P(d|h) \times P(h)}{P(d)}$$



The **prior probability** that I assigned to this hypothesis before observing the data

$$P(h|d) = \frac{P(d|h) \times P(h)}{P(d)}$$

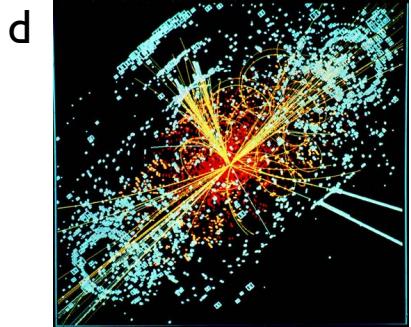
$d|h$



The likelihood that I would have observed these data if the hypothesis is true

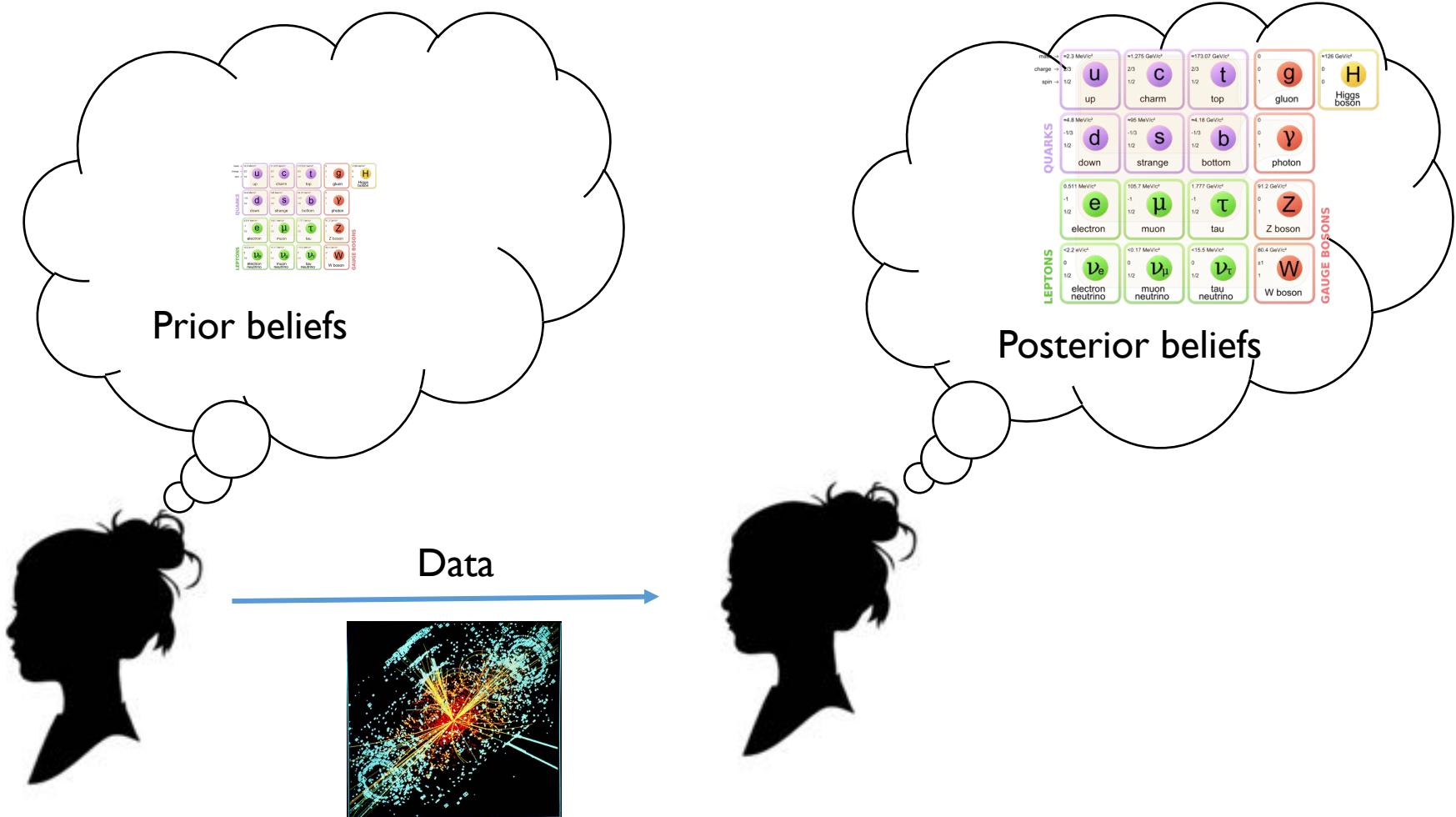
$$P(h|d) = \frac{P(d|h) \times P(h)}{P(d)}$$

$$P(h|d) = \frac{P(d|h) \times P(h)}{P(d)}$$



The “marginal” probability of observing these particular data (more on this shortly)

# Belief revision!



$P(d|h)$  : the likelihood of observing  $d$  if  $h$  is true

$P(h)$  : the prior probability that  $h$  is true

$P(h|d)$  : the posterior probability that  $h$  is true

$$P(h|d) = \frac{P(d|h)P(h)}{P(d)}$$

$P(d)$  : discussed later

## I.4 Example of Bayesian reasoning



# Many possibilities



dropped a wine glass



broke a window



psychic explosion



earthquake



a wizard did it

etc...

# Let's compare two of them



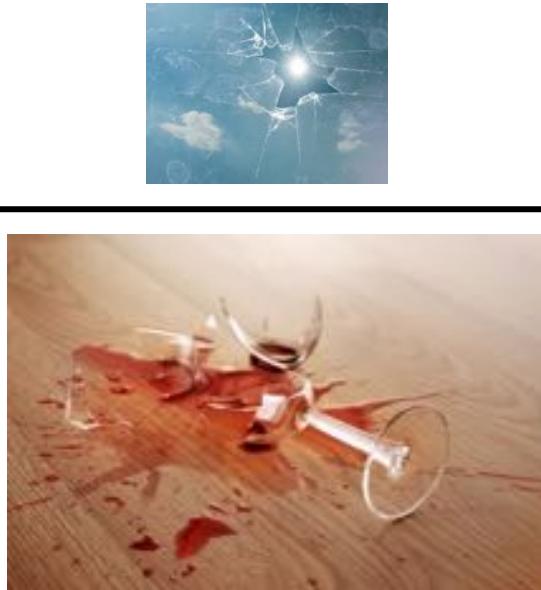
I dropped a wine glass



Kids broke the window

# “Prior odds”

$$\frac{P(h_1)}{P(h_2)} = \frac{\text{[broken window image]}}{\text{[broken wine glass image]}} = 0.1$$



Before learning anything else I think “wine glass dropping” is 10 times more plausible than “broken window”

# Some data



There is a cricket ball  
next to the broken glass

# Likelihood of the data

When I drop a wine glass...



... It's very unlikely that I just happen to do so right next to a cricket ball

$$P(d|h) = 0.001$$

# Likelihood of the data

When the kids break a window...



... It's not at all uncommon  
for a cricket ball to end up  
near the glass

$$P(d|h) = 0.15$$

# Bayes factor

(a.k.a. likelihood ratio)

$$\frac{P(d|h_1)}{P(d|h_2)} = \frac{\text{Image of a cricket ball next to a broken window}}{\text{Image of a wine glass next to a broken window}} = \frac{0.15}{0.001} = 150$$

I think it is 150 times more likely that I would find a cricket ball when a window breaks than when a wine glass is broken

# Posterior odds

$$\frac{P(h_1|d)}{P(h_2|d)} = \frac{P(d|h_1)}{P(d|h_2)} \times \frac{P(h_1)}{P(h_2)}$$

Posterior odds

= 15

Likelihood ratio

= 150

Prior odds

= .1



In light of the evidence, I now think the window-breaking hypothesis is 15 times more likely than the wine-glass hypothesis



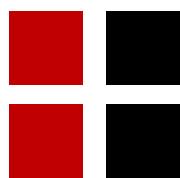
## 1.5 Bayesian hypothesis testing



8 red



2 black

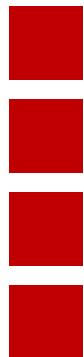


# Is this roulette wheel unbalanced?

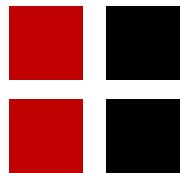


We're ignoring the zero

8 red



2 black



Null model,  $h_0$

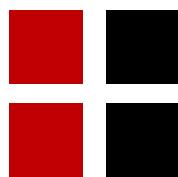
The roulette wheel has an equal probability of producing red and black



8 red



2 black



Null model,  $h_0$

The roulette wheel has an equal probability of producing red and black

$h_1$

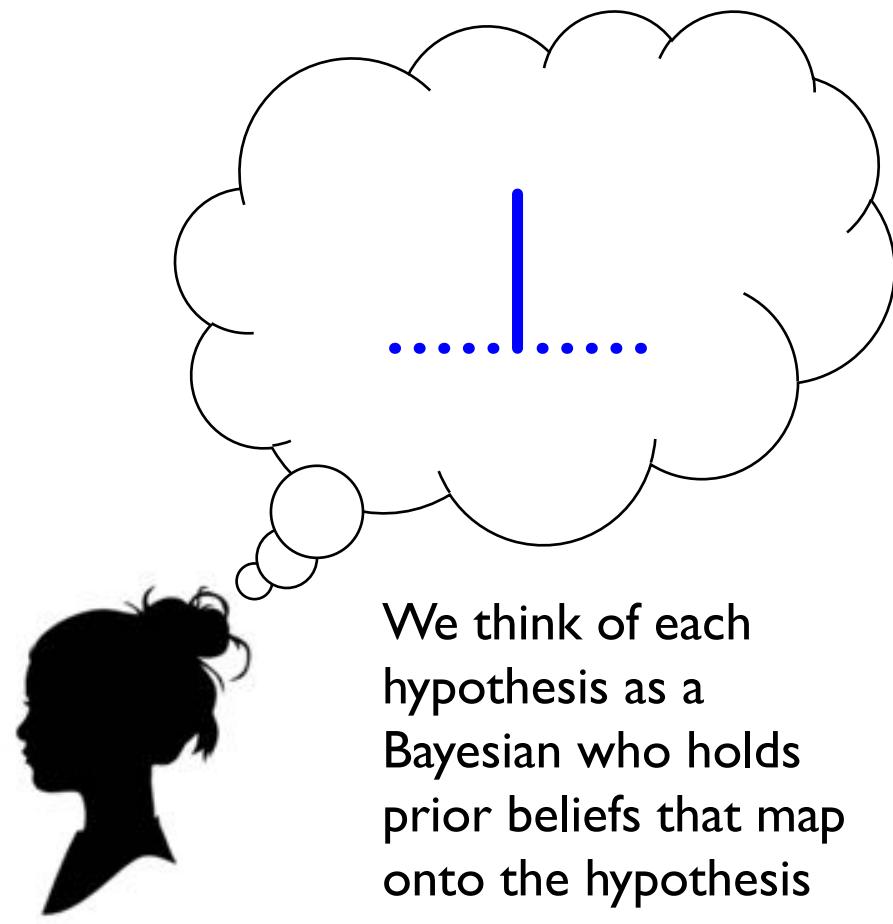
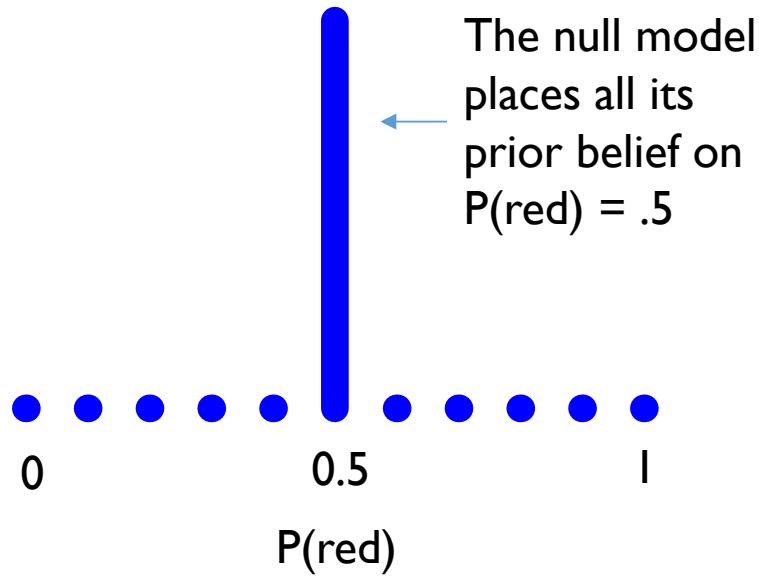
Alternative model,

The roulette wheel has a bias, but we don't know what it is



## Null hypothesis

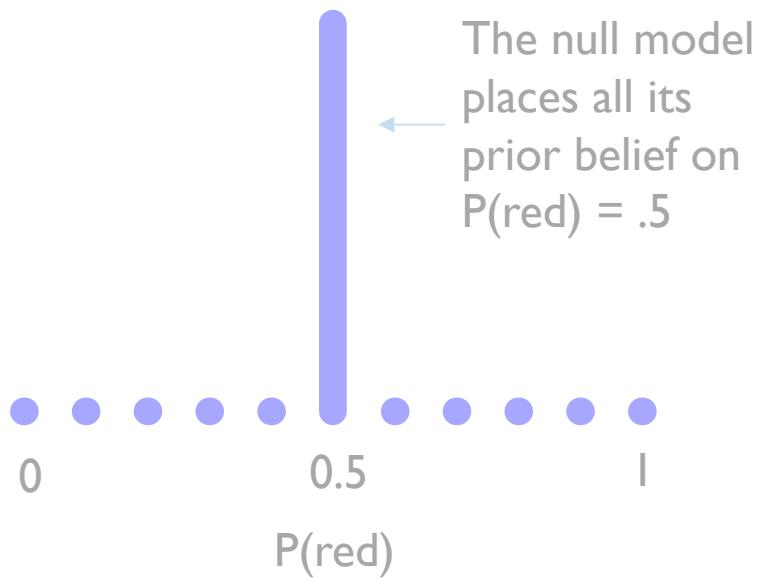
$$P(\theta|h_0)$$



Let's pretend that there's no such thing as "continuous numbers", and act as if the only possible values for  $P(\text{red})$  are 0, 0.1, 0.2, ..., 1.0 ☺

## Null hypothesis

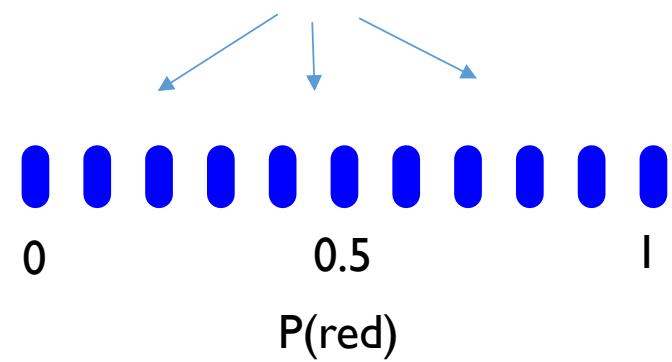
$$P(\theta|h_0)$$



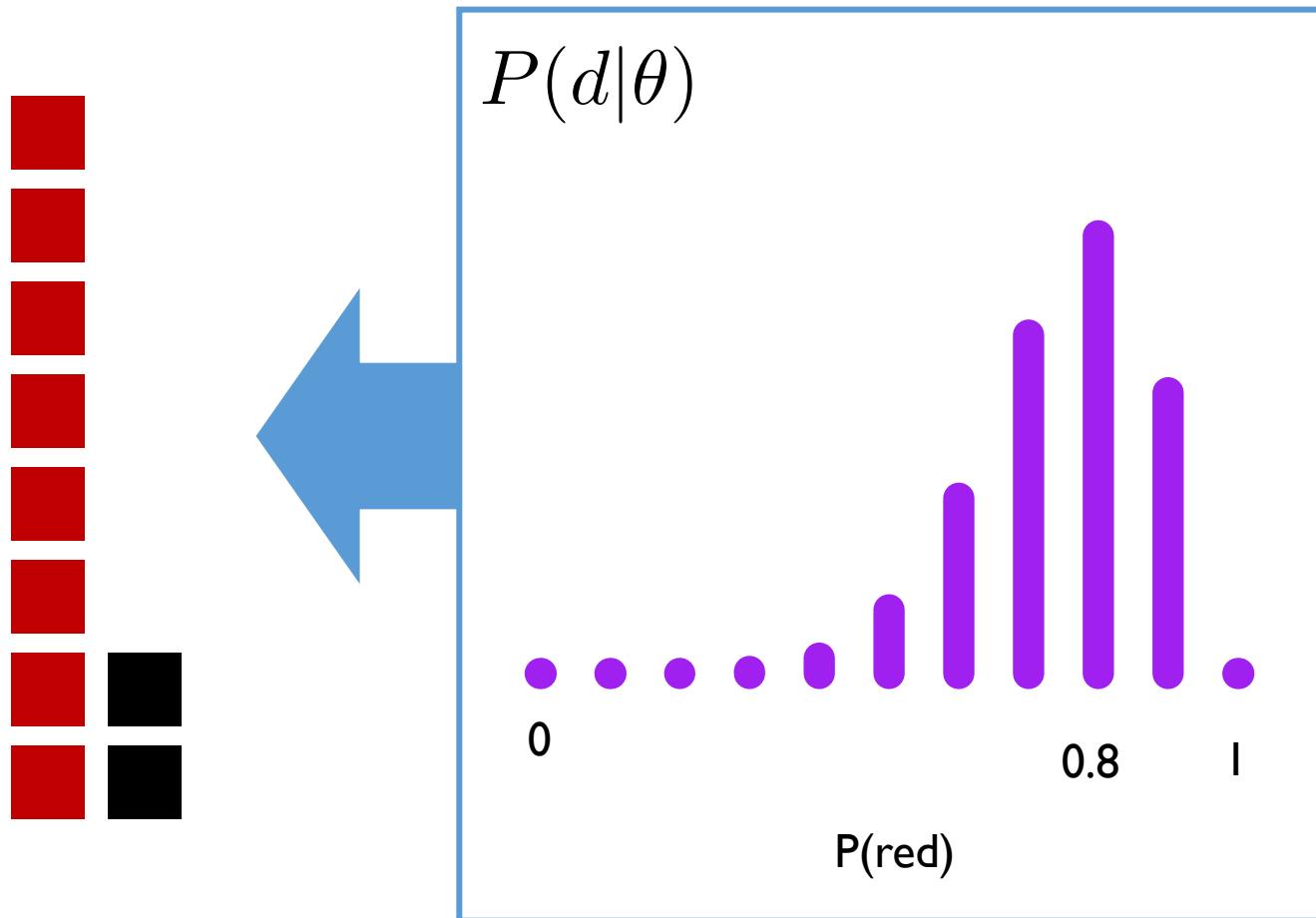
## Alternative hypothesis

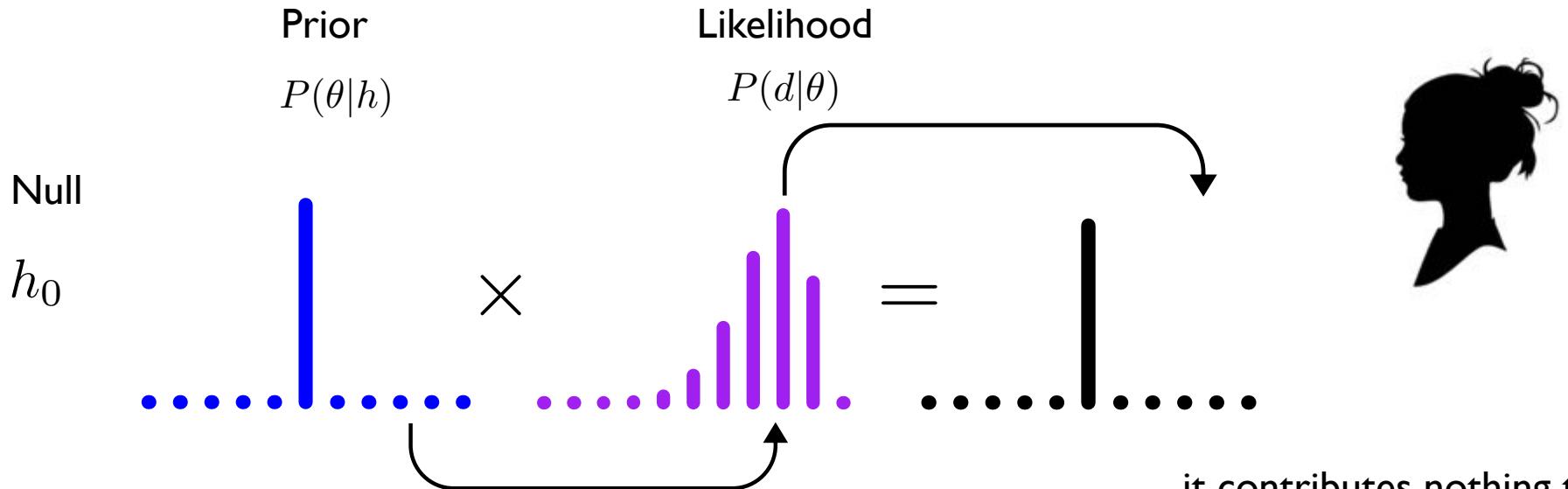
$$P(\theta|h_1)$$

The alternative model spreads its prior belief equally across all possibilities



Likelihoods ... the probability of the data given every possible value of  $P(\text{red})$

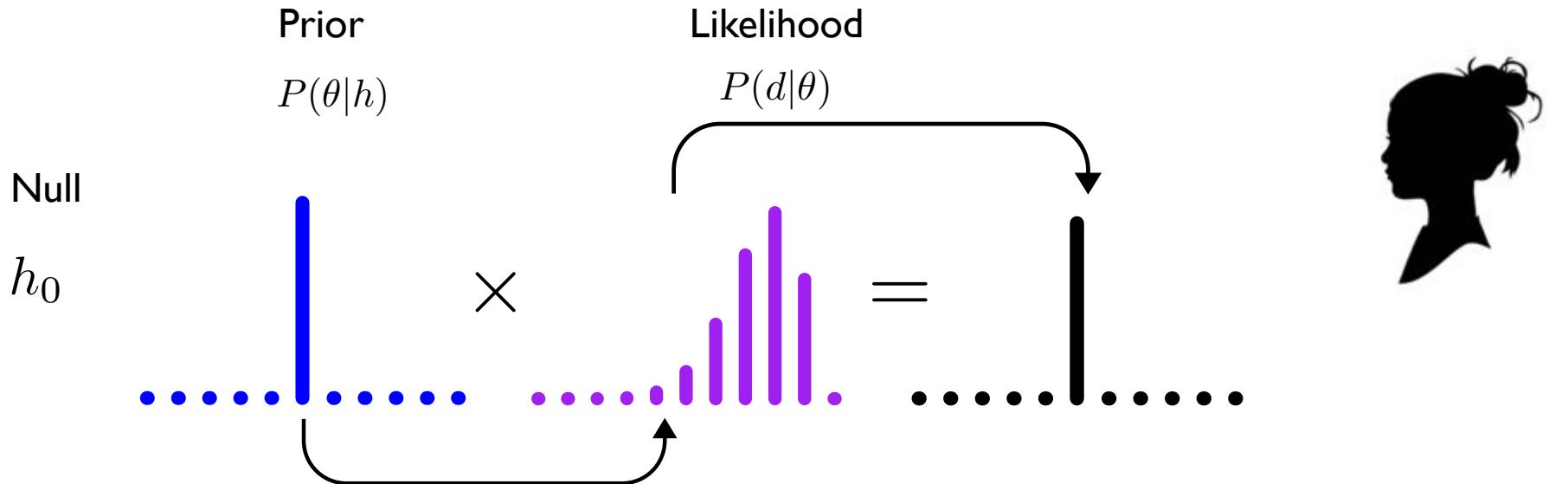




... it contributes nothing to  
the a priori “prediction”  
made by the null

The null hypothesis assigns prior probability 0 to the possibility that  $P(\text{red}) = 0.8 \dots$

... so even though it assigns highest likelihood to the observed data ....



... it is the only contributor to the prediction made by this model

The null hypothesis assigns prior probability 1 to the possibility that  $P(\text{red}) = 0.5 \dots$

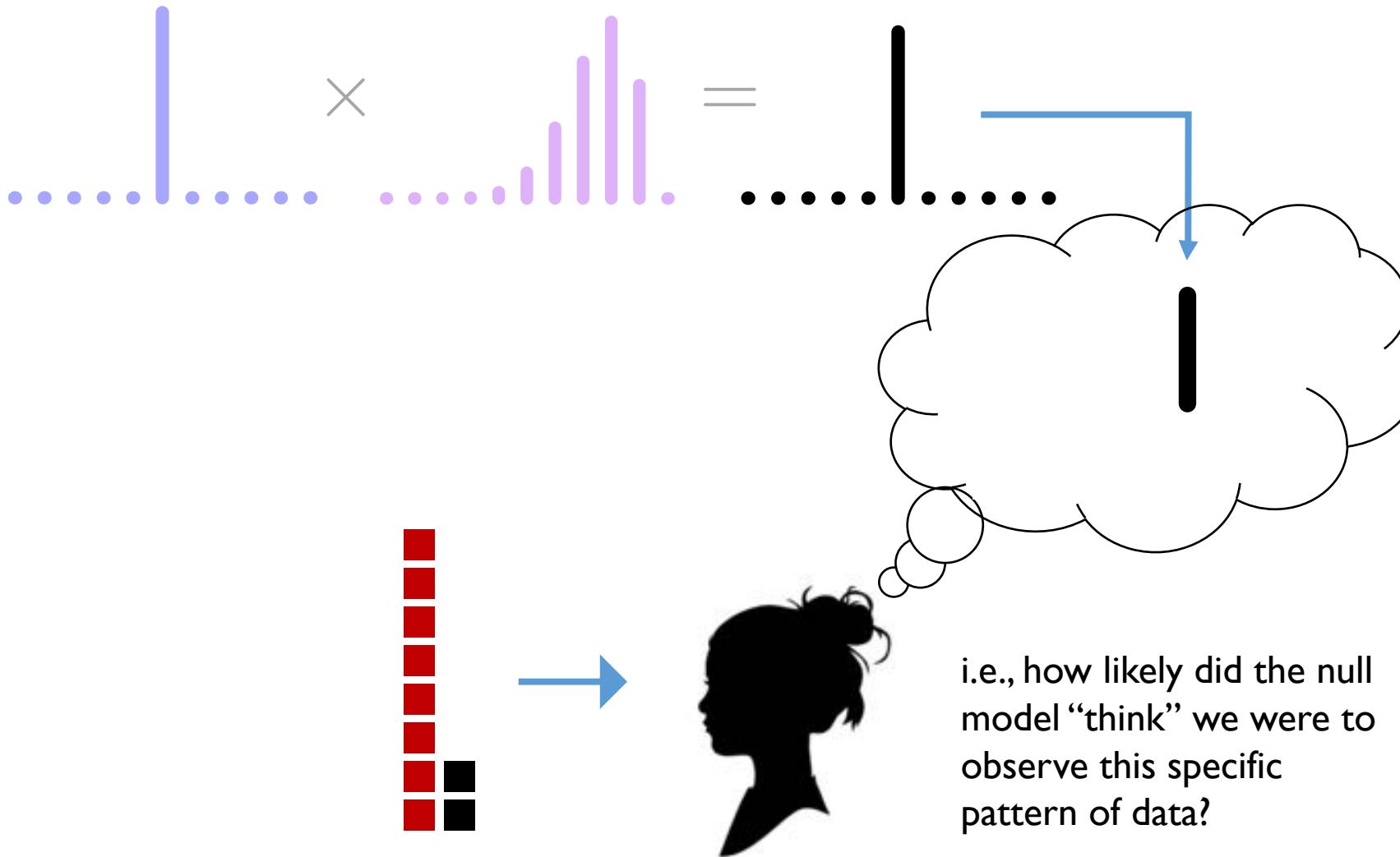
... so even though it assigns a pretty small likelihood to the observed data ....

Prior

Null

Likelihood

Summing these values gives the **marginal probability** of the data under the null hypothesis...



Prior

$$P(\theta|h)$$

Likelihood

$$P(d|\theta)$$

Marginal probability of  
the data according to  
both models

Null



$$h_0$$



$$P(d|h_0)$$

Alternative



$$h_1$$



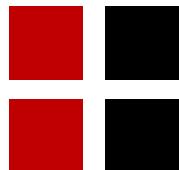
$$P(d|h_1)$$

# Data

8 red



2 black



# Models

Null model  $h_0$

The roulette wheel has an equal probability of producing red and black



Alternative model  $h_1$

The roulette wheel has a bias, but we don't know what it is

Bayes factor

$$P(d|h_0)$$

$$P(d|h_1)$$



... evidence of about 2:1 in favour of the alternative

$$BF_{10} = \frac{P(d|h_1)}{P(d|h_0)} = \frac{\sum_{\theta} P(d|\theta) \times P(\theta|h_0)}{\sum_{\theta} P(d|\theta) \times P(\theta|h_1)} = 1.87$$

## 2.1 Just another stats package

<https://jasp-stats.org>





# JASP

## A Fresh Way to Do Statistics

[Download](#)

# Illustrating the JASP workflow

## What?

open a CSV file  
descriptive statistics  
run a frequentist ANOVA  
save data and results to JASP file

## Where?

**File > Open**  
**Common > Descriptives**  
**Common > ANOVA > ANOVA**  
**File > Save As**

# Here's a real data set with many variables!

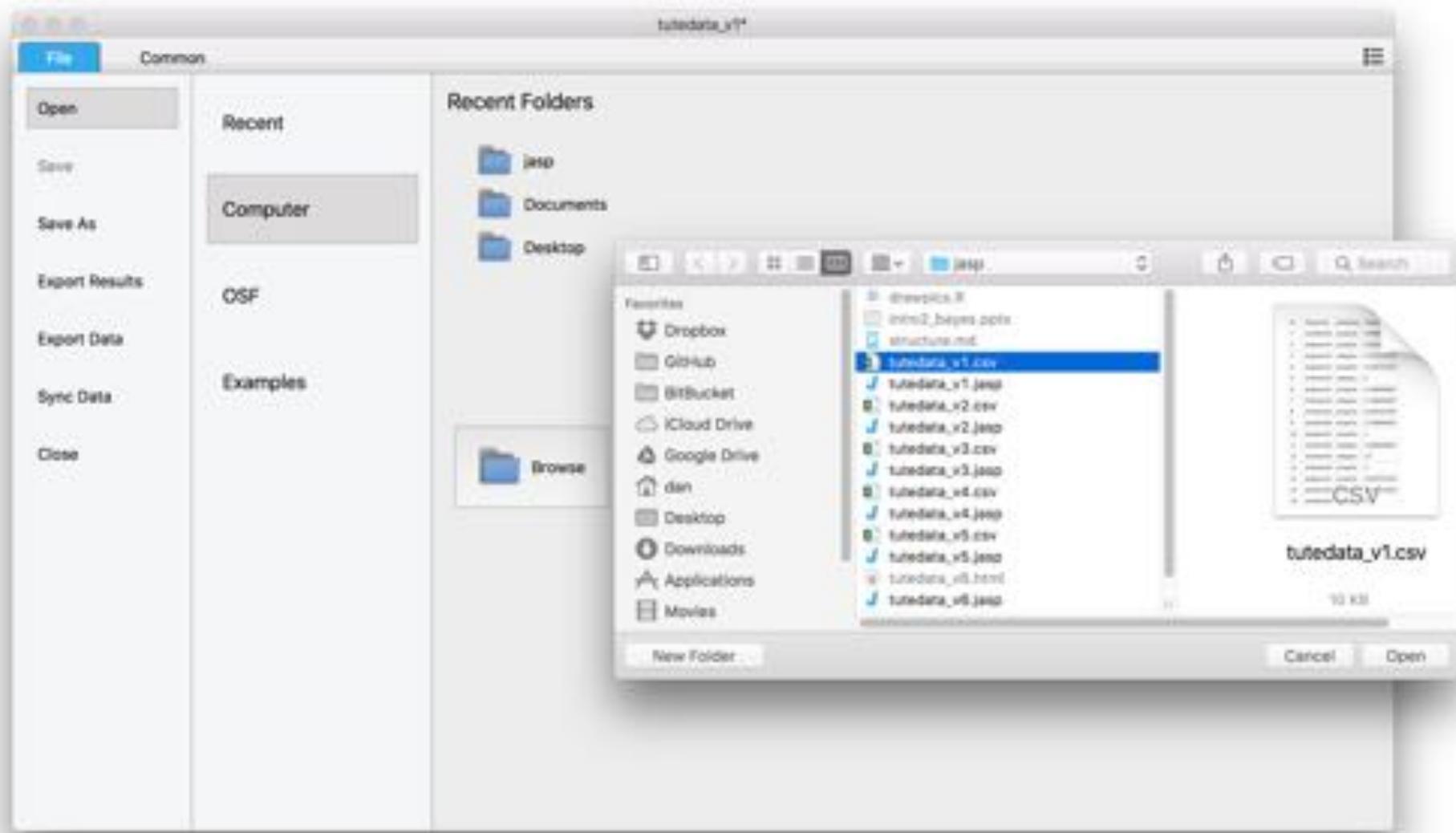
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	
1	id	age	gender	frequency	sampling	gen_smaller	gen_larger	gen_smaller	gen_larger	gen_smaller	gen_larger	meangen	smallworld	largeworld	property	category	condition	smallprop
2	1	21	female	smallworld	property	10	4	8	1	4	1	4.666666667	property	NA	smallworld	NA	smallworldproperty	yes
3	2	19	female	largeworld	property	9	4	6	3	5	2	4.833333333	NA	property	largeworld	NA	largeworldproperty	no
4	3	20	female	largeworld	category	9	4	3	3	4	3	4.333333333	NA	category	largeworld	NA	largeworldcategory	no
5	4	19	male	largeworld	property	9	3	5	2	5	2	4.333333333	NA	property	largeworld	NA	largeworldproperty	no
6	5	21	female	smallworld	category	3	5	8	9	4	7	6	category	NA	NA	smallworldcategory	no	
7	6	21	female	largeworld	property	8	3	5	5	5	5	5.166666667	NA	property	largeworld	NA	largeworldproperty	no
8	7	21	female	smallworld	category	10	5	5	1	5	5	5.166666667	category	NA	NA	smallworld	smallworldcategory	no
9	8	24	female	smallworld	property	10	5	5	1	20	10	6.833333333	property	NA	smallworld	NA	smallworldproperty	yes
10	9	19	female	smallworld	property	9	2	2	2	2	2	3.166666667	property	NA	smallworld	NA	smallworldproperty	yes
11	10	20	male	largeworld	property	8	5	2	2	4	3	4.666666667	NA	property	largeworld	NA	largeworldproperty	no
12	11	21	female	smallworld	category	10	10	5	6	1	6	5.666666667	category	NA	NA	smallworld	smallworldcategory	no
13	12	20	female	smallworld	category	8	5	4	6	5	5	5.5	category	NA	NA	smallworld	smallworldcategory	no
14	13	20	male	smallworld	property	10	2	2	1	2	1	3	property	NA	smallworld	NA	smallworldproperty	yes
15	14	19	female	largeworld	property	10	1	8	1	8	1	4.833333333	NA	property	largeworld	NA	largeworldproperty	no
16	15	21	male	smallworld	category	9	3	3	3	4	1	3.833333333	category	NA	smallworld	NA	smallworldcategory	no
17	16	24	female	smallworld	category	9	6	3	3	3	3	4.5	category	NA	NA	smallworld	smallworldcategory	no
18	17	20	male	smallworld	category	8	4	2	2	2	3	3.5	category	NA	NA	smallworld	smallworldcategory	no
19	18	20	male	smallworld	property	10	7	4	4	4	4	4.5	property	NA	smallworld	NA	smallworldproperty	yes
20	19	21	male	smallworld	property	10	5	5	5	5	5	5.833333333	property	NA	smallworld	NA	smallworldproperty	yes
21	20	21	female	smallworld	category	10	5	5	2	2	2	3.666666667	category	NA	NA	smallworld	smallworldcategory	no
22	21	19	male	largeworld	category	9	8	2	5	2	2	4.666666667	NA	category	largeworld	NA	largeworldcategory	no
23	22	19	male	smallworld	property	10	7	7	6	3	3	6	property	NA	smallworld	NA	smallworldproperty	yes
24	23	21	female	largeworld	category	10	9	4	4	5	5	5.166666667	NA	category	NA	largeworld	largeworldcategory	no
25	24	21	male	largeworld	property	10	3	7	1	7	1	4.5	NA	property	largeworld	NA	largeworldproperty	no
26	25	20	female	smallworld	property	10	5	2	2	2	2	3.833333333	property	NA	smallworld	NA	smallworldproperty	yes
27	26	19	female	smallworld	category	8	6	4	4	6	4	5	category	NA	smallworld	NA	smallworldcategory	yes
28	27	19	female	smallworld	property	9	2	3	3	3	3	3.833333333	property	NA	smallworld	NA	smallworldproperty	yes
29	28	20	male	smallworld	property	10	9	2	3	2	2	4.666666667	property	NA	smallworld	NA	smallworldproperty	yes
30	29	23	female	largeworld	property	9	3	3	1	3	1	3.333333333	NA	property	largeworld	NA	largeworldproperty	no
31	30	19	female	smallworld	category	10	7	2	2	4	2	4.5	category	NA	NA	smallworld	smallworldcategory	no
32	31	20	male	smallworld	property	10	8	2	2	2	2	4.333333333	property	NA	smallworld	NA	smallworldproperty	yes
33	32	20	female	largeworld	category	9	5	5	5	5	5	5.666666667	NA	category	largeworld	NA	largeworldcategory	no
34	33	23	female	smallworld	property	9	9	7	2	3	2	3.333333333	property	NA	smallworld	NA	smallworldproperty	yes
35	34	19	male	smallworld	category	10	8	7	6	7	7	7.5	category	NA	NA	smallworld	smallworldcategory	no
36	35	21	female	largeworld	category	9	5	3	6	6	6	5.833333333	NA	category	NA	largeworld	largeworldcategory	no
37	36	19	male	smallworld	property	8	5	3	3	3	4	4	property	NA	smallworld	NA	smallworldproperty	yes

JASP isn't (currently?) good for computing new variables, so it's best to do that in Excel or whatever you prefer

A	B	C	D
<b>id</b>	<b>frequency</b>	<b>sampling</b>	<b>meangen</b>
1	smallworld	property	4.67
2	largeworld	property	4.83
3	largeworld	category	4.33
4	largeworld	property	4.33
5	smallworld	category	6.00
6	largeworld	property	5.17
7	smallworld	category	5.17
8	smallworld	property	6.83
9	smallworld	property	3.17
10	largeworld	property	4.00
11	smallworld	category	5.67
12	smallworld	category	5.50
13	smallworld	property	3.00
14	largeworld	property	4.83
16	smallworld	category	3.83
18	smallworld	category	4.50
19	smallworld	category	3.50
20	smallworld	property	5.50

For simplicity I'll use small CSV files with only the relevant variables

## File > Open



## Common

The screenshot shows the JASP software interface. On the left, there is a data table titled "tutedata\_v1" with 20 rows and 5 columns. The columns are labeled: Id, frequency, sampling, meangen, and symmetry. The data consists of two categories: "smallworld" and "largeworld". The "frequency" column contains values like 4.666667, 4.833333, etc. The "sampling" column contains "property" and "category". The "meangen" column contains numerical values. On the right, there is a large blue banner with the JASP logo and the text "Welcome to JASP Version 0.8". Below the banner, it says "A Fresh Way to Do Statistics: Free, Friendly, and Inclusive". There is a bulleted list of features: "Free: JASP is an open-source project with structural support from the University of Amsterdam.", "Friendly: JASP has an intuitive interface that was designed with the user in mind.", and "Inclusive: JASP offers standard analysis procedures in both their classical and Bayesian manifestations.". At the bottom, it says "So open a data file and take JASP for a spin!" and "Double-click to edit data".

	Id	frequency	sampling	meangen
1	1	smallworld	property	4.666667
2	2	largeworld	property	4.833333
3	3	largeworld	category	4.333333
4	4	largeworld	property	4.333333
5	5	smallworld	category	6
6	6	largeworld	property	5.166667
7	7	smallworld	category	6.166667
8	8	smallworld	property	6.833333
9	9	smallworld	property	3.166667
10	10	largeworld	property	4
11	11	smallworld	category	5.666667
12	12	smallworld	category	5.5
13	13	smallworld	property	3
14	14	largeworld	property	4.833333
15	15	smallworld	category	3.833333
16	16	smallworld	category	4.5
17	17	smallworld	category	3.5
18	18	smallworld	symmetry	5.5

# Common > Descriptives

Screenshot of the SPSS "Common > Descriptives" dialog box.

The dialog shows the following settings:

- Variables selected for analysis: id, frequency, sampling, meangen.
- Output options:
  - Display frequency tables (nominal and ordinal variables)
  - Plots (selected)
  - Statistics (selected)

The results panel displays the Descriptive Statistics table:

	id	frequency	sampling	meangen
Valid	286	286	286	286
Missing	0	0	0	0
Mean	173.0			4.917
Std. Deviation	99.19			1.152
Minimum	1.000			2.333
Maximum	342.0			9.000

Note: Not all values are available for Nominal Text variables.

# Common > ANOVA

The screenshot shows the SPSS software interface with the title bar "fulldata.sav". The menu bar has "File", "Edit", "View", "Common", "Analyze", "Transform", "Data", "Utilities", and "Help". The "Common" tab is selected. In the toolbar, there are icons for Descriptives, T-Tests, ANOVA (which is highlighted in blue), Regression, Frequencies, and Factor. A data table is visible on the left, and a results pane on the right labeled "Results".

**ANOVA**

- Repeated Measures ANOVA
- ANCOVA
- Bayesian ANOVA
- Bayesian Repeated Measures ANOVA
- Bayesian ANCOVA

	ID	frequency	
1	1	smallworld	
2	2	largeworld	
3	3	largeworld	
4	4	largeworld	property 4.33333
5	5	smallworld	category 6
6	6	largeworld	property 5.16667
7	7	smallworld	category 6.16667
8	8	smallworld	property 6.83333
9	9	smallworld	property 3.16667
10	10	largeworld	property 4
11	11	smallworld	category 5.66667
12	12	smallworld	category 5.5
13	13	smallworld	property 3
14	14	largeworld	property 4.83333
15	15	smallworld	category 3.83333
16	16	smallworld	category 4.5
17	17	smallworld	category 3.5
18	18	smallworld	frequency 5.5

# Common > ANOVA > ANOVA

The screenshot shows the SPSS interface with the 'Common' tab selected. On the left, a data view window displays a table with columns 'Id' and 'frequency', and rows labeled 1 through 19. The 'frequency' column contains values 'smallworld' and 'largeworld'. In the center, the 'ANOVA' dialog box is open. The 'Dependent Variable' dropdown contains 'frequency'. The 'Fixed Factors' dropdown is empty. Below these are 'WLS Weights' and a list of options: Model, Assumption Checks, Contrasts, Post Hoc Tests, Descriptives Plots, and Additional Options. On the right, the 'Results' viewer shows the 'ANOVA' section, which includes the ANOVA table and notes about Type III Sum of Squares.

File Common

Descriptives T-Tests ANOVA Regressions Frequencies Factor

	Id	frequency
1	1	smallworld
2	2	largeworld
3	3	largeworld
4	4	largeworld
5	5	smallworld
6	6	largeworld
7	7	smallworld
8	8	smallworld
9	9	smallworld
10	10	largeworld
11	11	smallworld
12	12	smallworld
13	13	smallworld
14	14	largeworld
15	15	smallworld
16	16	smallworld
17	17	smallworld

Dependent Variable: frequency

Fixed Factors:

WLS Weights

- Model
- Assumption Checks
- Contrasts
- Post Hoc Tests
- Descriptives Plots
- Additional Options

## Results

### ANOVA

ANOVA

Cases	Sum of Squares	df	Mean Squ
Residual	-	-	-

Note. Type III Sum of Squares

# Common > ANOVA > ANOVA

The screenshot shows the SPSS interface with the following components:

- File** tab is selected in the top menu.
- Common** tab is selected in the top-left toolbar.
- Data** view window on the left displays a table with columns **Id** and **frequency**, and rows numbered 1 to 17. The data shows alternating values between "smallworld" and "largeworld".
- ANOVA** dialog box is open in the center:
  - Dependent Variable:** meangen
  - Fixed Factors:** frequency, sampling
  - WLS Weights:** (button)
  - Model** (selected):
    - Assumption Checks
    - Contrasts
    - Post Hoc Tests
    - Descriptives Plots
    - Additional Options
- Results** window on the right displays the ANOVA table:

	Cases	Sum of Squares	df
frequency	3.947	1	
sampling	55.762	1	
frequency * sampling	5.429	1	
Residual	313.523	282	

Note: Type III Sum of Squares

# Common > ANOVA > ANOVA > Descriptive Plots

Screenshot of SPSS software interface showing the 'Descriptive Plots' dialog box and results for an ANOVA analysis.

**File**   **Common**   **T-Tests**   **ANOVA**   **Regression**   **Frequencies**   **Factor**

**Results**

### ANOVA

ANOVA - meangen

Cases	Sum of Squares	df
frequency	3.947	1
sampling	55.762	1
frequency * sampling	5.429	1
Residual	313.523	282

Note: Type III Sum of Squares

**Descriptive Plots** Dialog Box:

- Model
- Assumption Checks
- Contrasts
- Post Hoc Tests
- Descriptives Plots

**Factors**: frequency, sampling

**Horizontal axis**: (empty)

**Display**:  
Error bars displaying:  
 Confidence interval  
 Standard error  
Interval: 95 %

**Additional Options**: (empty)

# Common > ANOVA > ANOVA > Descriptive Plots

Screenshot of SPSS software interface showing the ANOVA dialog box and resulting output.

**SPSS Menu Path:** Common > ANOVA > ANOVA > Descriptive Plots

**Data View:**

	Id	frequency
1	1	smallworld
2	2	largeworld
3	3	largeworld
4	4	largeworld
5	5	smallworld
6	6	largeworld
7	7	smallworld
8	8	smallworld
9	9	smallworld
10	10	largeworld
11	11	smallworld
12	12	smallworld
13	13	smallworld
14	14	largeworld
15	15	smallworld
16	16	smallworld
17	17	smallworld
18	18	smallworld
19	19	smallworld

**ANOVA Dialog Box:**

- Model
- Assumption Checks
- Contrasts
- Post Hoc Tests
- Descriptives Plots

**Factors:**

- Horizontal axis: frequency
- Separate lines: sampling
- Separate plots

**Display:**

- Error bars displaying
- Confidence interval
- Interval: 95 %
- Standard error

**Additional Options:**

**Output View:**

### ANOVA

ANOVA - meangen

Cases	Sum of Squares	df
frequency	3.947	
sampling	55.762	
frequency * sampling	5.429	
Residual	313.523	28

Note. Type III Sum of Squares

### Descriptives

#### Descriptives Plot

The plot shows two data points connected by a horizontal line. The left point is at approximately 1.5 and the right point is at approximately 4.5. Both points have vertical error bars representing confidence intervals. The y-axis is labeled 'meangen'.

# Common

Untitleddata\_v11

File Common

Descriptives T-Tests ANOVA Regression Frequencies Factor

	id	frequency	sampling	meangen
1	1	smallworld	property	4.666667
2	2	largeworld	property	4.833333
3	3	largeworld	category	4.333333
4	4	largeworld	property	4.333333
5	5	smallworld	category	6
6	6	largeworld	property	5.166667
7	7	smallworld	category	6.166667
8	8	smallworld	property	6.833333
9	9	smallworld	property	3.166667
10	10	largeworld	property	4
11	11	smallworld	category	5.666667
12	12	smallworld	category	5.5
13	13	smallworld	property	3
14	14	largeworld	property	4.833333
15	15	smallworld	category	3.833333
16	16	smallworld	category	4.5
17	17	smallworld	category	3.5
18	18	smallworld	property	5.5
19	19	smallworld	property	6.833333

**ANOVA**

ANOVA - meangen

Cases	Sum of Squares	df	Mean Square	F	p
frequency	3.947	1	3.947	3.551	0.061
sampling	55.762	1	55.762	50.156	<.001
frequency + sampling	5.429	1	5.429	4.884	0.028
Residual	313.523	282	1.112		

Note. Type III Sum of Squares

**Descriptives**

**Descriptives Plot**

The plot displays two data series: 'category' (represented by open circles) and 'property' (represented by solid black circles). The x-axis is labeled 'frequency' and has two categories: 'largeworld' and 'smallworld'. The y-axis is labeled 'meangen' and ranges from 4 to 6. The 'category' series shows a mean value of approximately 5.5 for both 'largeworld' and 'smallworld'. The 'property' series shows a mean value of approximately 3.5 for 'largeworld' and 5.5 for 'smallworld'. Error bars are present on all data points.

frequency	sampling	meangen
largeworld	category	5.5
smallworld	category	5.5
largeworld	property	3.5
smallworld	property	5.5

# Common

Saved data: tutodata.xlsx

File Common

Descriptives T-Tests ANOVA Regression Frequencies

	Id	frequency	sampling	meanger
1	1	smallworld	property	4.666667
2	2	largeworld	property	4.833333
3	3	largeworld	category	4.333333
4	4	largeworld	property	4.333333
5	5	smallworld	category	6
6	6	largeworld	property	5.166667
7	7	smallworld	category	6.166667
8	8	smallworld	property	6.833333
9	9	smallworld	property	3.166667
10	10	largeworld	property	4
11	11	smallworld	category	5.666667
12	12	smallworld	category	5.5
13	13	smallworld	property	3
14	14	largeworld	property	4.833333
15	15	smallworld	category	3.833333
16	16	smallworld	category	4.5
17	17	smallworld	category	4.6

Factor

	Frequency	Sampling	Frequency + Sampling	Residual	p-value
Frequency	3.947	3	3.947	3.551	0.063
sampling	55.762	3	55.762	50.156	< .001
frequency + sampling	5.429	3	5.429	4.884	0.028
Residual	313.523	282	1.112		

Note: Type III Sum of Squares

Descriptives ▾

- Collapse
- Copy
- Add Note

sampling  
● category  
● property

meanger

frequency

largeworld smallworld

# Common

Saved

tutedata.xlsx

File Common

Descriptives T-Tests ANOVA Regression Frequencies Factor

	id	frequency	sampling	meangen
1	1	smallworld	property	4.666667
2	2	largeworld	property	4.833333
3	3	largeworld	category	4.333333
4	4	largeworld	property	4.333333
5	5	smallworld	category	6
6	6	largeworld	property	5.166667
7	7	smallworld	category	6.166667
8	8	smallworld	property	6.833333
9	9	smallworld	property	3.166667
10	10	largeworld	property	4
11	11	smallworld	category	5.666667
12	12	smallworld	category	5.5
13	13	smallworld	property	3
14	14	largeworld	property	4.833333
15	15	smallworld	category	3.833333
16	16	smallworld	category	4.5
17	17	smallworld	category	3.5

**Descriptives**

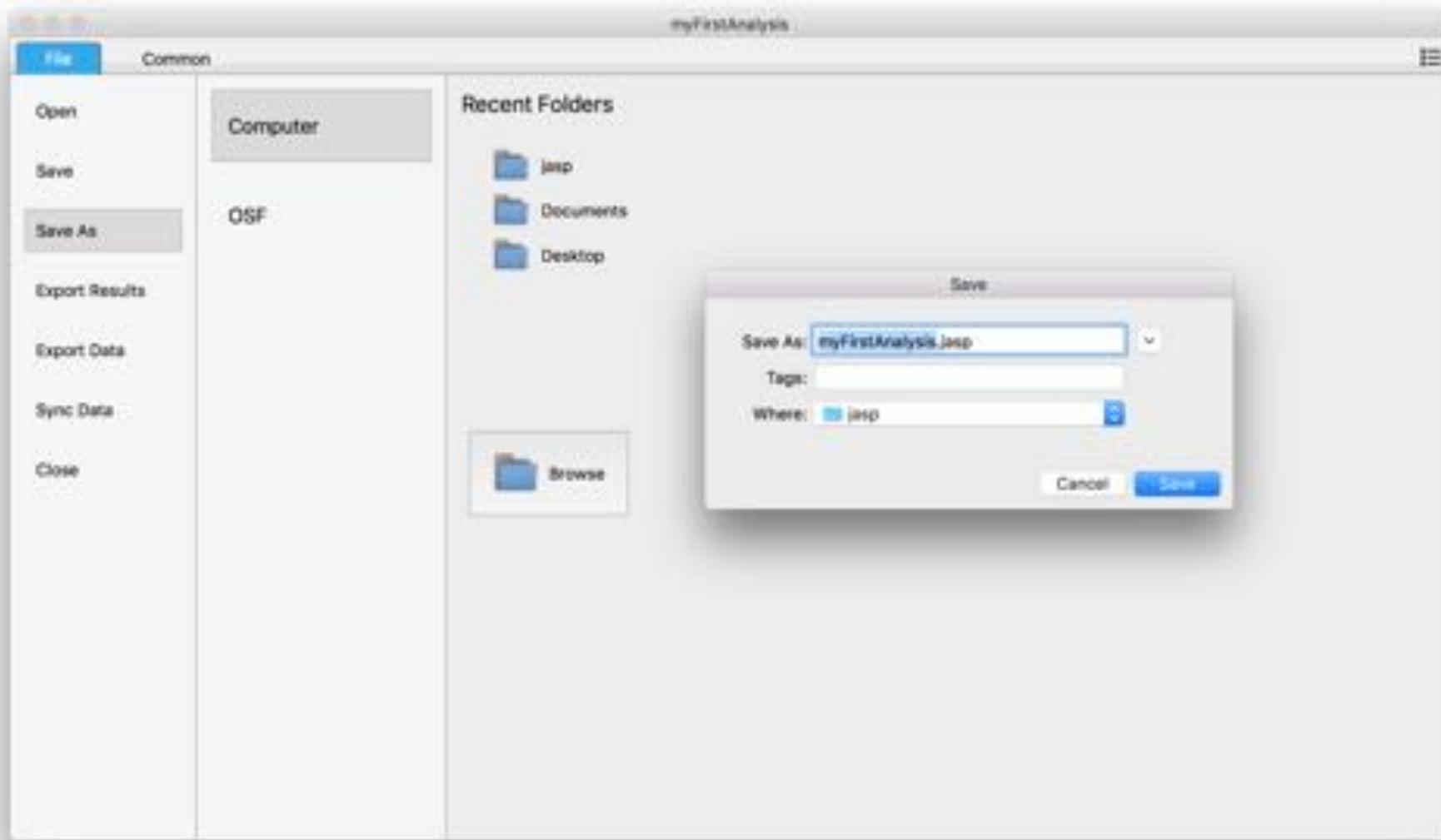
This pattern of interaction is exactly what we predicted ahead of time: a null effect of frequency information under category sampling, whereas generalisation is higher in the "small" world than in the "large" world under property sampling. Yay! My theory works!

**Descriptives Plot**

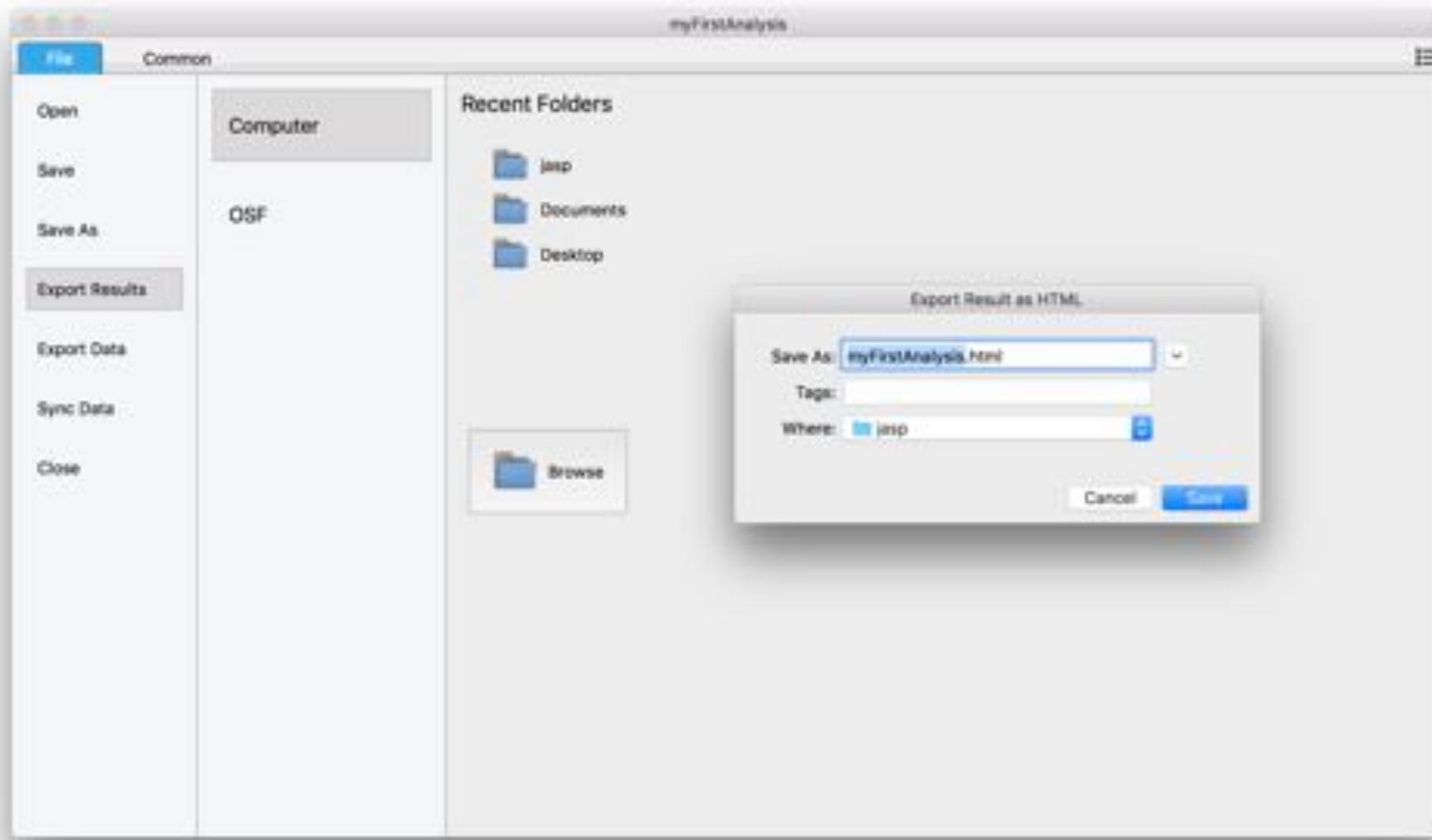
The plot shows two data series: 'category' (open circles) and 'property' (filled circles). The x-axis is labeled 'frequency' with categories 'largeworld' and 'smallworld'. The y-axis is labeled 'meangen' with values 4 and 6. The 'category' series has points at approximately (largeworld, 5.5) and (smallworld, 5.5). The 'property' series has points at approximately (largeworld, 4.5) and (smallworld, 5.5). Error bars are shown for each point.

frequency	sampling	meangen
largeworld	category	5.5
smallworld	category	5.5
largeworld	property	4.5
smallworld	property	5.5

## File > Save As



## File > Export Results



## 2.2 Bayesian ANOVA



# Common > ANOVA > Bayesian ANOVA

Saved data: my1\*

File Common

Descriptives T-Tests ANOVA Regression Frequencies Factor

Frequency sampling meangen

1	1	smallworld	property	4.66667
2	2	largeworld	property	4.83333
3	3	largeworld	category	4.33333
4	4	largeworld	property	4.33333
5	5	smallworld	category	6
6	6	largeworld	property	5.16667
7	7	smallworld	category	5.16667
8	8	smallworld	property	6.83333
9	9	smallworld	property	3.16667
10	10	largeworld	property	4
11	11	smallworld	category	5.66667
12	12	smallworld	category	5.5
13	13	smallworld	property	3
14	14	largeworld	property	4.83333
15	15	smallworld	category	3.83333
16	16	smallworld	category	4.5
17	17	smallworld	category	3.5
18	18	smallworld	property	5.5
19	19	smallworld	property	5.83333

Id

Dependent Variable: meangen

Fixed Factors: frequency, sampling

Random Factors:

Bayes Factor

$\text{BF}_n$

$\text{BF}_m$

Log( $\text{BF}_m$ )

Output

Effects

Descriptives

Order

Compare to null model

Compare to best model

Model

Descriptives Plots

Advanced Options

Results

### Bayesian ANOVA

Model Comparison - meangen

Models
Null model
frequency
sampling
frequency + sampling
Frequency + sampling = freq

### Analysis of Effects - meangen

Effects	P
frequency	0
sampling	0
frequency + sampling	0

# Common > ANOVA > Bayesian ANOVA

Saved data: ./tutdata.csv

File Common Descriptives T-Tests ANOVA Regression Frequencies Factor

### ANOVA

ANOVA - meangen

Cases	Sum of Squares	df	Mean Square	F	p
frequency	3.947	1	3.947	3.551	0.061
sampling	55.762	1	55.762	50.156	<.001
frequency * sampling	5.429	1	5.429	4.884	0.028
Residual	313.523	282	1.112		

Note: Type III Sum of Squares

### Bayesian ANOVA

Model Comparison - meangen

Models	P(M)	P(M data)	BF <sub>M</sub>	BF <sub>10</sub>	error %
Null model	0.200	1.195e-9	4.780e-9	1.000	
frequency	0.200	3.823e-10	1.529e-9	0.320	1.317e-5
sampling	0.200	0.309	1.792	2.590e+8	2.988e-14
frequency + sampling	0.200	0.255	1.387	2.132e+8	0.849
frequency + sampling + frequency * sampling	0.200	0.436	3.089	3.647e+8	1.110

Analysis of Effects - meangen

Effects	P(incl)	P(incl data)	BF <sub>Inclusion</sub>
frequency	0.600	0.693	1.488
sampling	0.600	1.000	4.227e+8
frequency * sampling	0.200	0.436	3.089

## Common > ANOVA > Bayesian ANOVA

### Model Comparison – meangen

Models	P(M)	P(M data)	BFM	BF10	error %
Null model	0.200	1.195e -9	4.780e -9	1.000	
frequency	0.200	3.823e -10	1.529e -9	0.320	1.317e -5
sampling	0.200	0.309	1.792	2.590e +8	2.988e -14
frequency + sampling	0.200	0.255	1.367	2.132e +8	0.849
frequency + sampling + frequency*sampling	0.200	0.436	3.089	3.647e +8	1.130

### Analysis of Effects – meangen

Effects	P(incl)	P(incl data)	BFinclusion
frequency	0.600	0.691	1.488
sampling	0.600	1.000	4.227e +8
frequency*sampling	0.200	0.436	3.089

## 2.3 Bayesian t-test

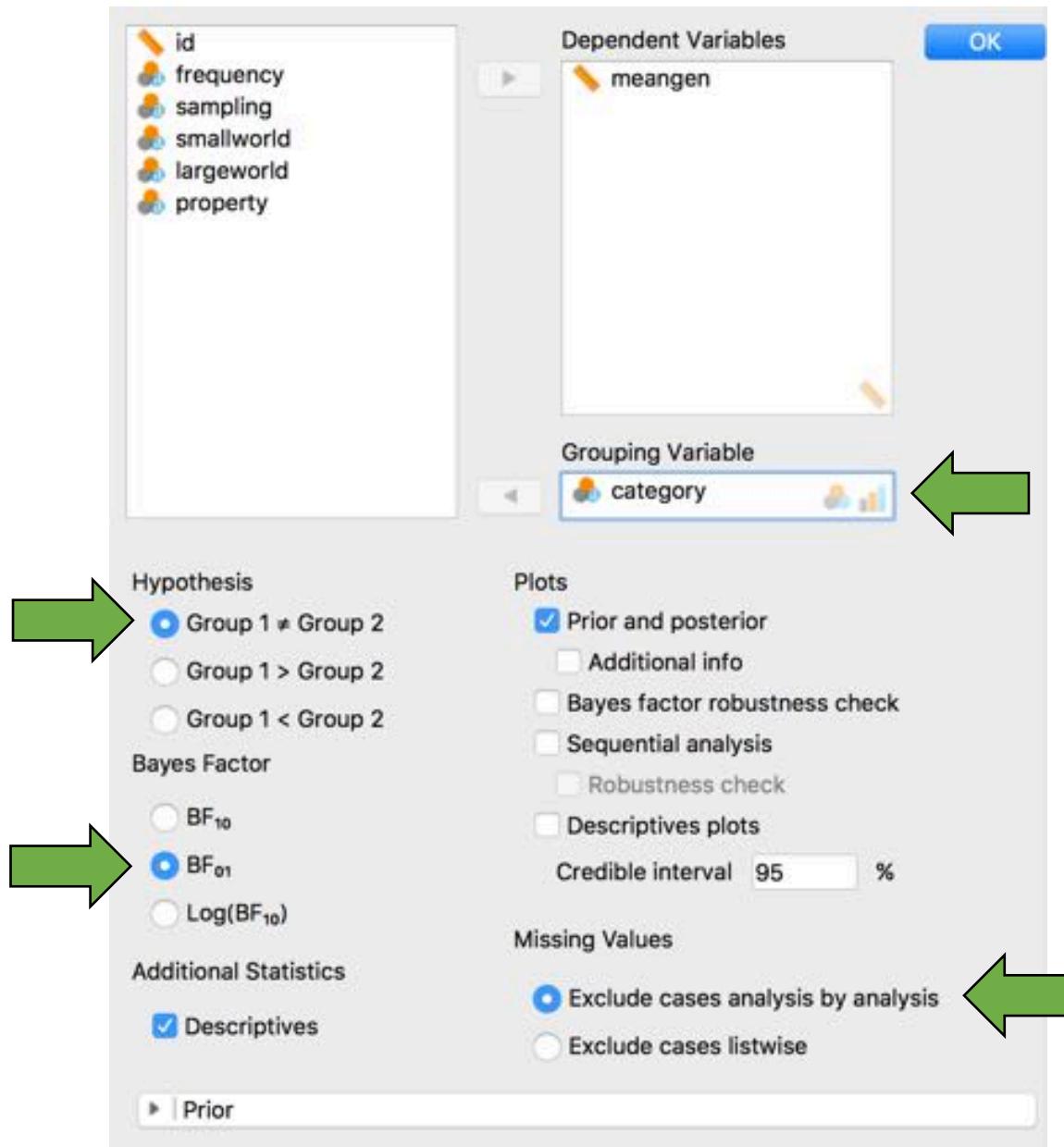


# Planned analysis #1:

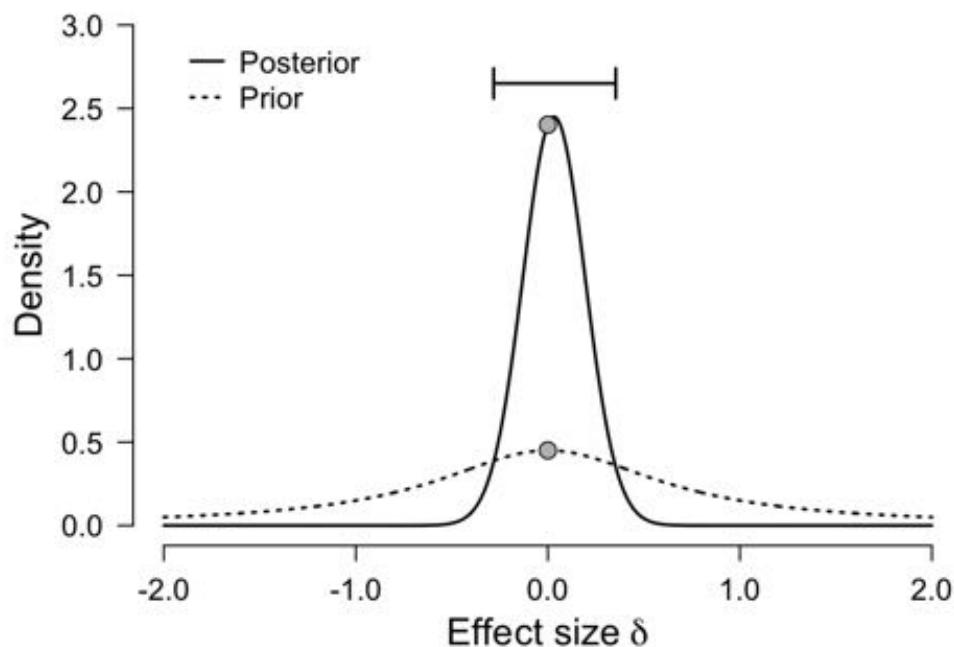
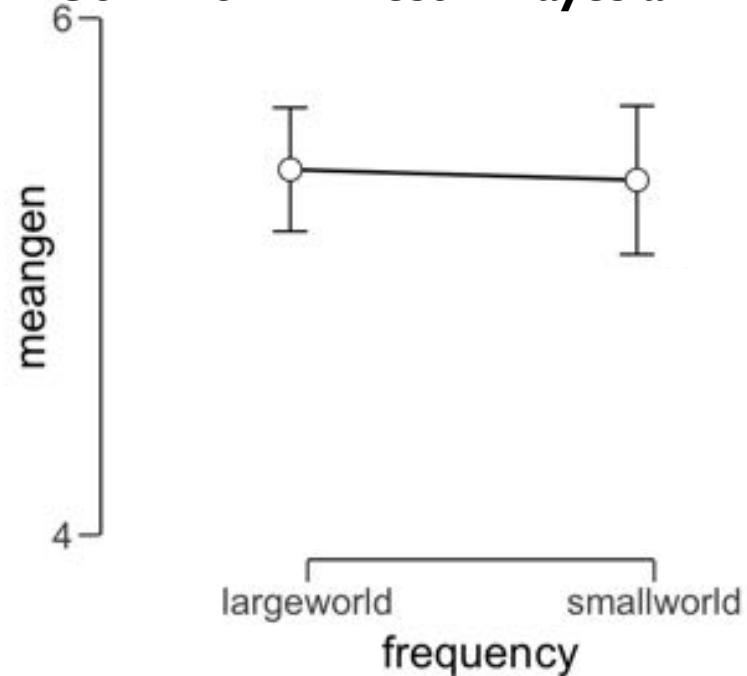
## Null effect under category sampling?

id	frequency	sampling	meangen	smallworld	largeworld	property	category
1	smallworld	property	4.67	property		smallworld	
2	largeworld	property	4.83		property	largeworld	
3	<b>largeworld</b>	<b>category</b>	<b>4.33</b>		<b>category</b>		<b>largeworld</b>
4	largeworld	property	4.33		property	largeworld	
5	<b>smallworld</b>	<b>category</b>	<b>6.00</b>	<b>category</b>			<b>smallworld</b>
6	largeworld	property	5.17		property	largeworld	
7	<b>smallworld</b>	<b>category</b>	<b>5.17</b>	<b>category</b>			<b>smallworld</b>
8	smallworld	property	6.83	property		smallworld	
9	smallworld	property	3.17	property		smallworld	
10	largeworld	property	4.00		property	largeworld	
11	<b>smallworld</b>	<b>category</b>	<b>5.67</b>	<b>category</b>			<b>smallworld</b>
12	<b>smallworld</b>	<b>category</b>	<b>5.50</b>	<b>category</b>			<b>smallworld</b>
13	smallworld	property	3.00	property		smallworld	

## Common > T-Test > Bayesian Independent Samples T-Test



## Common > T-Test > Bayesian Independent Samples T-Test



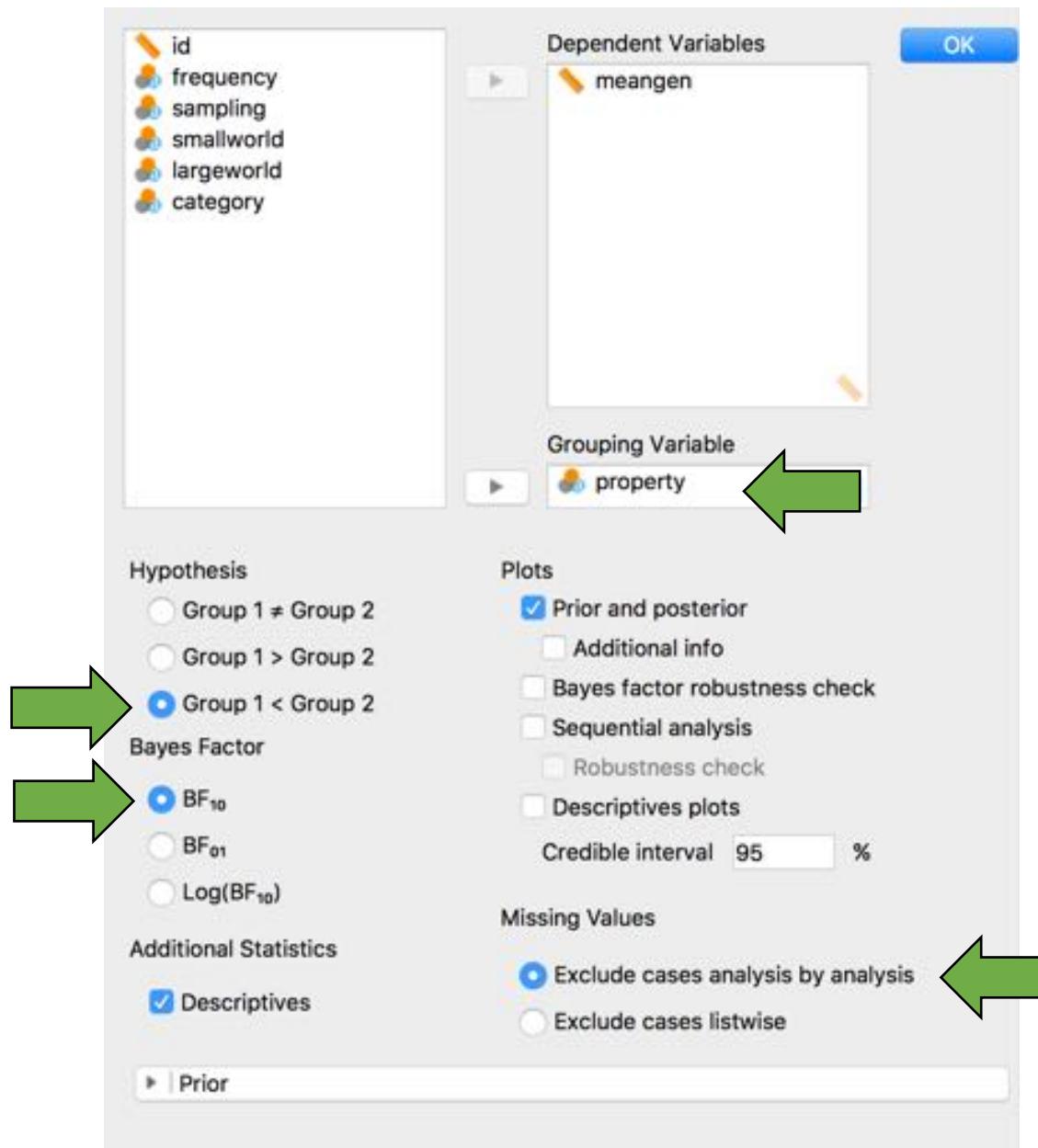
### Bayesian Independent Samples T-Test

	$BF_{01}$	error %
meangen	5.305	9.941e - 7

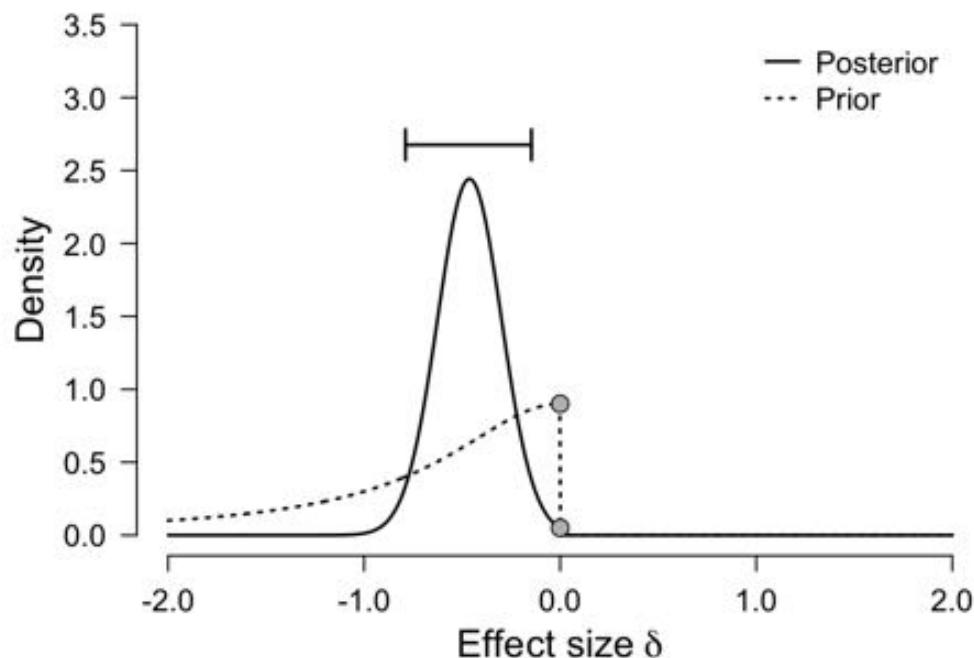
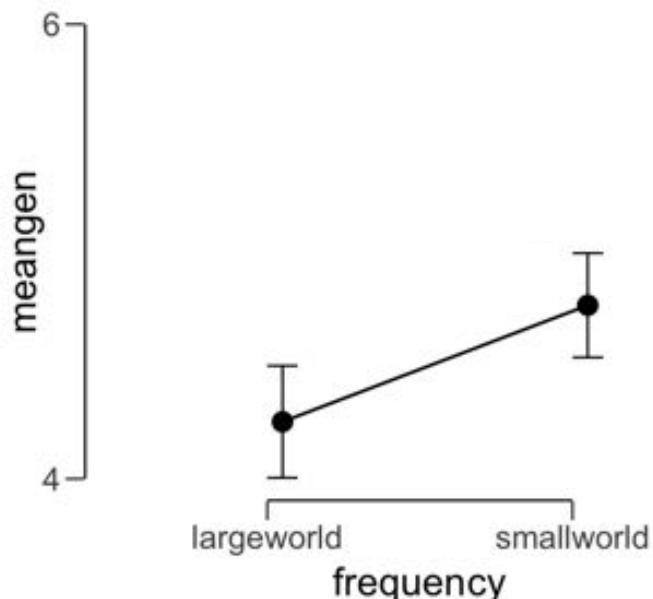
# Planned analysis #2: large < small under property sampling

id	frequency	sampling	meangen	smallworld	largeworld	property	category
1	smallworld	property	4.67	property		smallworld	
2	largeworld	property	4.83		property	largeworld	
3	largeworld	category	4.33		category		largeworld
4	largeworld	property	4.33		property	largeworld	
5	smallworld	category	6.00	category			smallworld
6	largeworld	property	5.17		property	largeworld	
7	smallworld	category	5.17	category			smallworld
8	smallworld	property	6.83	property		smallworld	
9	smallworld	property	3.17	property		smallworld	
10	largeworld	property	4.00		property	largeworld	
11	smallworld	category	5.67	category			smallworld
12	smallworld	category	5.50	category			smallworld
13	smallworld	property	3.00	property		smallworld	

## Common > T-Test > Bayesian Independent Samples T-Test



## Common > T-Test > Bayesian Independent Samples T-Test



### Bayesian Independent Samples T-Test ▾

	$BF_{-0}$	error %
meangen	22.49	$\sim 3.662e-6$

Note. For all tests, the alternative hypothesis specifies that group *largeworld* is less than group *smallworld*.

## 2.4 Bayesian regression



<b>id</b>	<b>age</b>	<b>small</b>	<b>property</b>	<b>female</b>	<b>meangen</b>
1	21	1	1	1	4.67
2	19	0	1	1	4.83
3	20	0	0	1	4.33
4	19	0	1	0	4.33
5	21	1	0	1	6.00
6	31	0	1	1	5.17
7	21	1	0	1	5.17
8	24	1	1	1	6.83
9	19	1	1	1	3.17
10	20	0	1	0	4.00
11	21	1	0	1	5.67
12	20	1	0	1	5.50
13	20	1	1	0	3.00
14	19	0	1	1	4.83
16	21	1	0	0	3.83
18	24	1	0	1	4.50
19	20	1	0	0	3.50
20	20	1	1	0	5.50

## Common > Regression > Bayesian Linear Regression

The screenshot shows the 'Bayesian Linear Regression' dialog box in SPSS. The dependent variable is 'meangen'. Covariates include 'age', 'small', 'property', and 'female'. In the 'Bayes Factor' section, 'BF<sub>10</sub>' is selected. Under 'Output', 'Effects' is checked. In the 'Order' section, 'Compare to best model' is selected. Three green arrows point to the 'BF<sub>10</sub>' selection, the checked 'Effects' checkbox, and the 'Compare to best model' selection.

id

Dependent Variable  
meangen

Covariates  
age  
small  
property  
female

Bayes Factor  
 BF<sub>10</sub>  
 BF<sub>01</sub>  
 Log(BF<sub>10</sub>)

Output  
 Effects

Order  
 Compare to null model  
 Compare to best model

## Common > Regression > Bayesian Linear Regression

### Model Comparison - meangen ▼

Models	P(M)	P(M data)	BFM	BF10	error %
property	0.063	0.326	7.243	1.000	
small + property	0.063	0.234	4.572	0.717	0.012
age + small + property	0.063	0.151	2.663	0.463	0.012
age + property	0.063	0.141	2.457	0.432	0.012
property + female	0.063	0.050	0.791	0.154	0.013
small + property + female	0.063	0.043	0.678	0.133	0.012
age + small + property + female	0.063	0.030	0.471	0.093	0.013
age + property + female	0.063	0.025	0.392	0.078	0.012
Null model	0.063	6.055e -10	9.083e -9	1.860e -9	0.012
age	0.063	3.438e -10	5.157e -9	1.056e -9	0.012
small	0.063	1.745e -10	2.617e -9	5.358e -10	0.012
age + small	0.063	1.697e -10	2.546e -9	5.211e -10	0.013
female	0.063	1.023e -10	1.535e -9	3.142e -10	0.012
age + female	0.063	7.768e -11	1.165e -9	2.385e -10	0.014
age + small + female	0.063	4.557e -11	6.835e -10	1.399e -10	0.012
small + female	0.063	4.301e -11	6.451e -10	1.321e -10	0.015

## Common > Regression > Bayesian Linear Regression

### Analysis of Effects – meangen ▼

Effects	P(incl)	P(incl data)	BFinclusion
age	0.500	0.347	0.532
small	0.500	0.458	0.845
property	0.500	1.000	6.402e +8
female	0.500	0.149	0.175

## 2.5 Bayesian contingency tables



<b>id</b>	<b>age</b>	<b>small</b>	<b>property</b>	<b>female</b>	<b>meangen</b>
1	21	1	1	1	4.67
2	19	0	1	1	4.83
3	20	0	0	1	4.33
4	19	0	1	0	4.33
5	21	1	0	1	6.00
6	31	0	1	1	5.17
7	21	1	0	1	5.17
8	24	1	1	1	6.83
9	19	1	1	1	3.17
10	20	0	1	0	4.00
11	21	1	0	1	5.67
12	20	1	0	1	5.50
13	20	1	1	0	3.00
14	19	0	1	1	4.83
16	21	1	0	0	3.83
18	24	1	0	1	4.50
19	20	1	0	0	3.50
20	20	1	1	0	5.50

tutedata5.csv

## Common > Frequencies > Bayesian Contingency Tables

The screenshot shows the 'Rows' and 'Columns' sections of the Bayesian Contingency Tables dialog. In the 'Rows' section, the variable 'small' is assigned, indicated by a right-pointing arrow and a small icon. In the 'Columns' section, the variable 'property' is assigned, also indicated by a right-pointing arrow and a small icon. On the left side of the dialog, there is a list of variables: 'id', 'age', 'female', and 'meangen'. Each variable has a corresponding icon next to its name.

Rows

small

Columns

property

id  
age  
female  
meangen

## Common > Frequencies > Bayesian Contingency Tables

▼ | Statistics

**Sampling**

- Poisson
- Joint multinomial
- Indep. multinomial, rows fixed
- Indep. multinomial, columns fixed
- Hypergeometric (2x2 only)

**Hypothesis**

- Group one  $\neq$  Group two
- Group one  $>$  Group two
- Group one  $<$  Group two

**Bayes Factor**

- $BF_{10}$
- $BF_{01}$
- $\text{Log}(BF_{10})$

## Common > Frequencies > Bayesian Contingency Tables

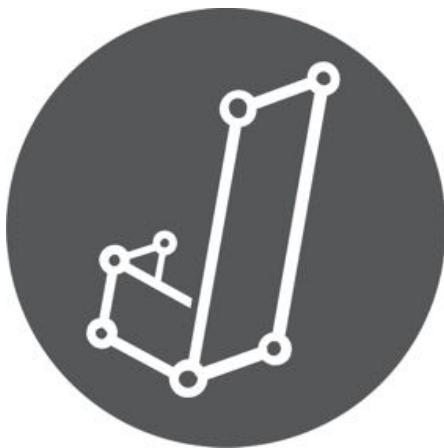
### Bayesian Contingency Tables ▾

small	property		Total
	0	1	
0	73	71	144
1	62	78	140
Total	135	149	284

### Bayesian Contingency Tables Tests

	Value
$BF_{01}$ joint multinomial	2.540
N	284

## 2.6 Bayesian binomial test



<b>spin</b>	<b>outcome</b>
1	red
2	red
3	red
4	black
5	red
6	red
7	red
8	black
9	red
10	red

## Common > Frequencies > Bayesian Binomial Test

spin      outcome      OK

Test value: 0.5

Hypothesis

≠ Test value  
 > Test value  
 < Test value

Plots

Prior and posterior  
 Additional info  
 Sequential analysis

Bayes Factor

$BF_{10}$   
  $BF_{01}$   
 Log( $BF_{10}$ )

Prior

Beta prior: parameter a 1  
Beta prior: parameter b 1

casino\*

File Common

Descriptives T-Tests ANOVA Regression Frequencies Factor

	spin	outcome
1	1	red
2	2	red
3	3	red
4	4	black
5	5	red
6	6	red
7	7	red
8	8	black
9	9	red
10	10	red

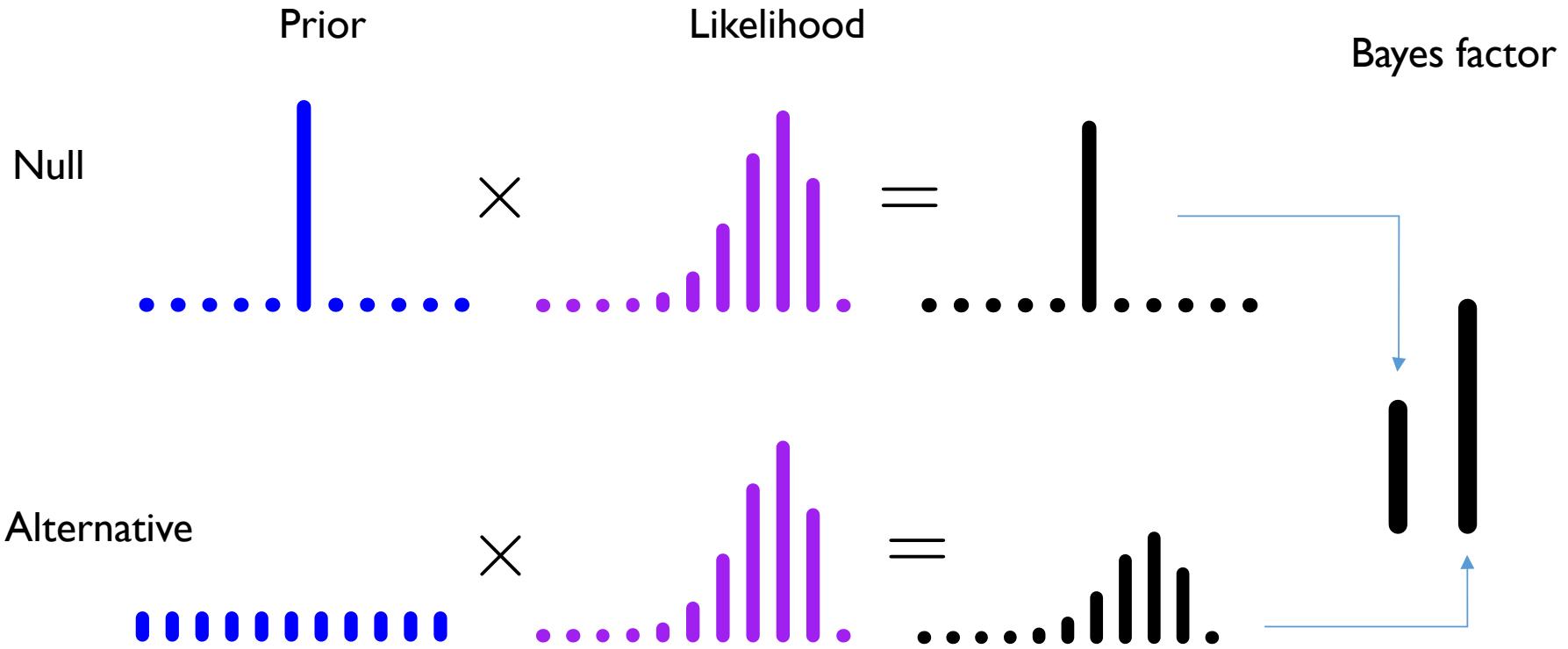
## Results

### Bayesian Binomial Test

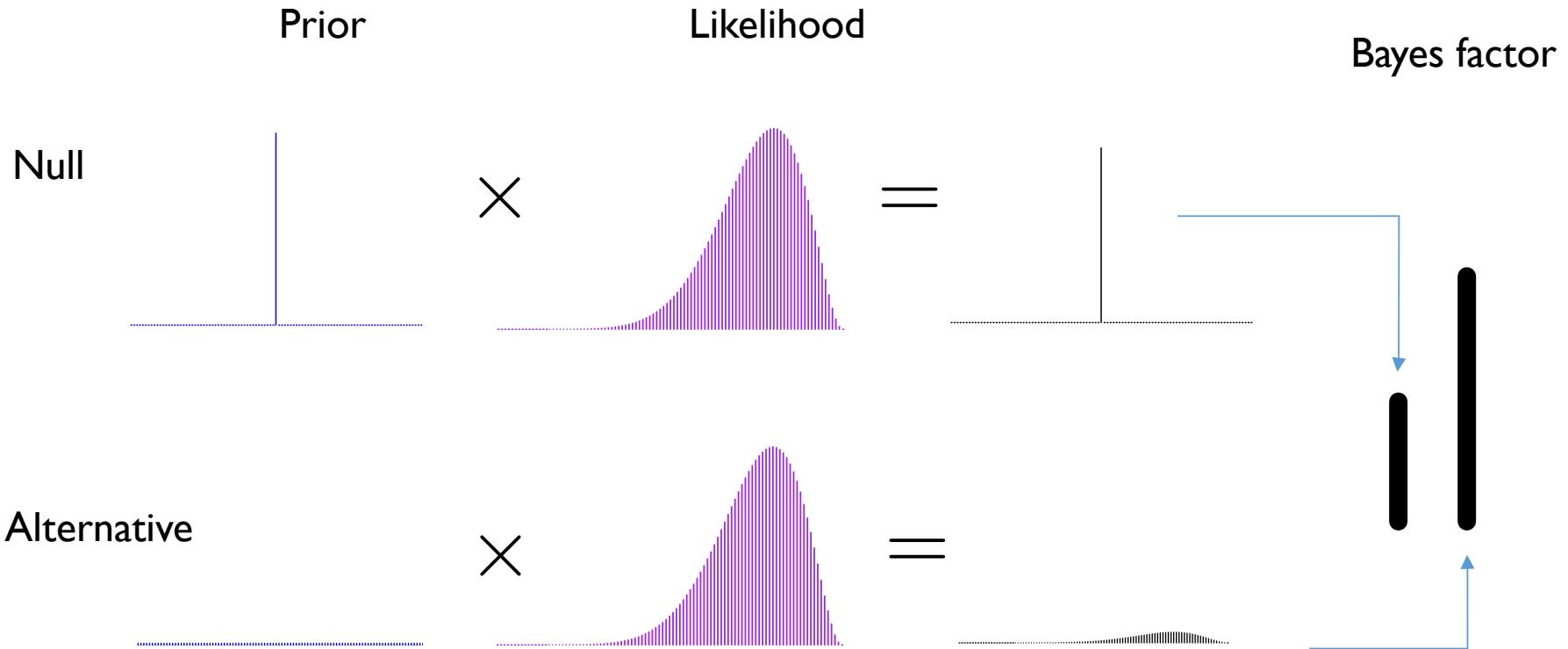
Bayesian Binomial Test

	Level	Counts	Total	Proportion	$BF_{10}$
outcome	black	2	10	0.200	2.069
	red	8	10	0.800	2.069

Note. Proportions tested against value: 0.5.



Wait... we got 1.87 for this  
Bayes factor and JASP says 2.07



It's just an approximation error... if  
we use finer-grained approximation  
to "continuous numbers" we get 2.05

## 2.7 Beyond basics



... to be added at a later stage!

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

Done!