浙江大学 心理与行为科学系
DEPARTMENT OF PSYCHOLOGY AND BEHAVIORAL SCIENCES
ZHEJIANG UNIVERSITY

6.使用JASP进行贝叶斯数据分析

戴俊毅

研究员/长聘副教授

JASP简介

- JASP是荷兰阿姆斯特丹大学Wagenmakers实验室开发的一套类似于SPSS的开源统计分析软件。它既可以完成常用的频率学派统计学的数据分析，也可以进行贝叶斯统计学的数据分析。
- 现有的常用贝叶斯推断统计分析技术包括
    1. 集中趋势差异检验
    2. 方差分析（协方差分析）
    3. 混合模型
    4. 相关/回归分析
    5. 频次分析
- JASP可执行的统计分析模块在不断更新之中。

描述统计

Sleep

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor

Descriptive Statistics

ID

Variables: extra

Split: group

Frequency tables (nominal and ordinal variables)

Plots

Customizable plots
Color palette: Colorblind
Boxplots
Boxplot element
Violin element
Jitter element
Use color palette
Label outliers

Basic plots
Distribution plots
Display density
Correlation plots
Q-Q plots
Pie charts

Descriptive Statistics

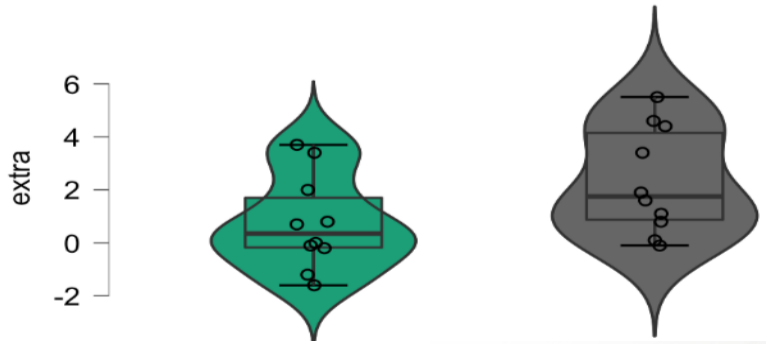
First, we will create the descriptives statistics split by the group (type of drug). Then, we create a plot of the data.

Descriptive Statistics

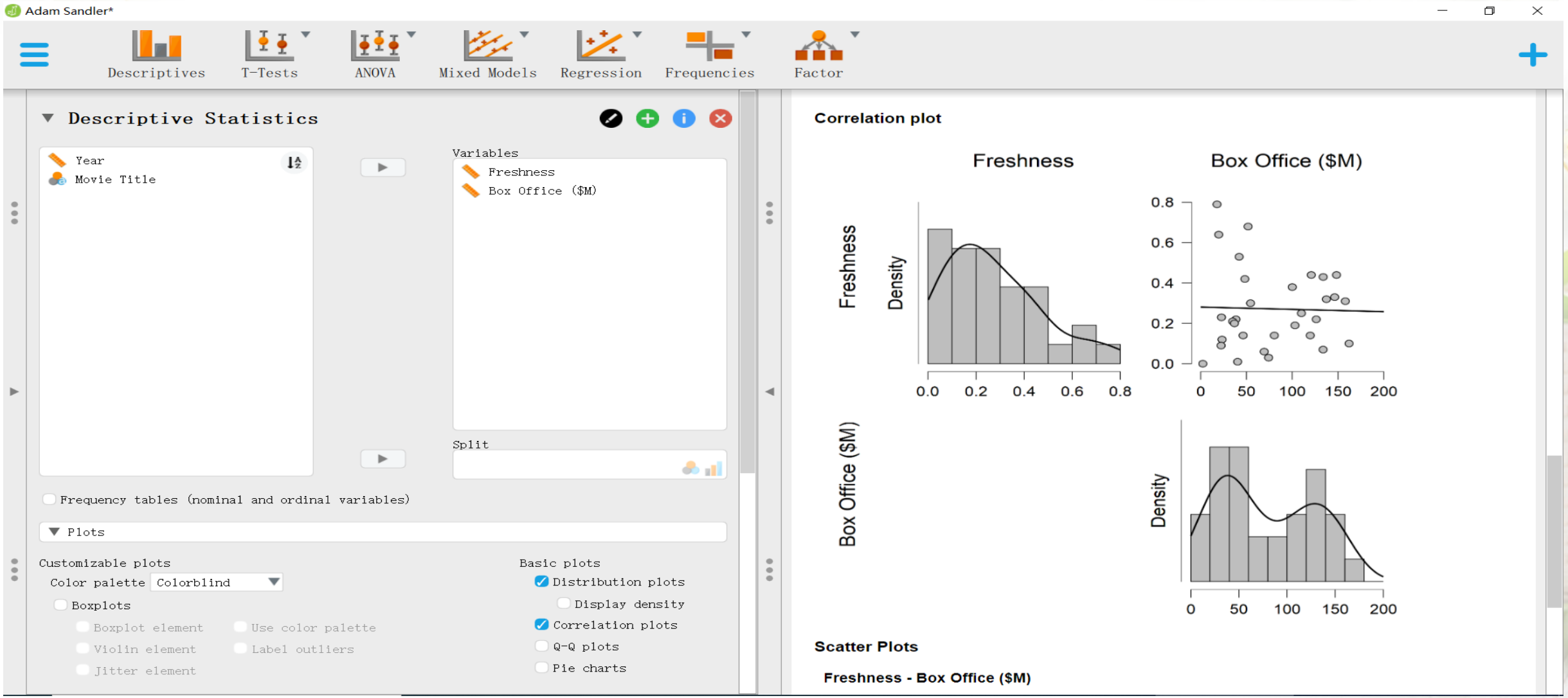
	extra	
	1	2
Valid	10	10
Missing	0	0
Mean	0.750	2.330
Std. Deviation	1.789	2.002
Minimum	−1.600	−0.100
Maximum	3.700	5.500

Boxplots

extra



描述统计


Adam Sandler*
Descriptives
T-Tests
ANOVA
Mixed Models
Regression
Frequencies
Factor
Descriptive Statistics
Year
Movie Title
Variables
Freshness
Box Office ($M)
Split
Frequency tables (nominal and ordinal variables)
Plots
Customizable plots
Color palette
Colorblind
Boxplots
Boxplot element
Violin element
Jitter element
Use color palette
Label outliers
Basic plots
Distribution plots
Display density
Correlation plots
Q-Q plots
Pie charts
Correlation plot
Freshness
Box Office ($M)
Density
Scatter Plots
Freshness - Box Office ($M)

贝叶斯推断统计分析主要设置

- 备择假设类型
- 贝叶斯因子计算方式
- 检验类型
- 贝叶斯因子稳健性检测
- 序列检验
- 先验分布参数
- 先验和后验分布图例
- 可信区间

独立样本t检验

Eye Movements

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor

Bayesian Independent Samples T-Test

ParticipantNumber

Dependent Variables
- CriticalRecall

Grouping Variable
- Condition

Alt. Hypothesis
- Group 1 ≠ Group 2
- Group 1 > Group 2
- Group 1 < Group 2

Bayes Factor
- BF_{10}
- BF_{01}
- $\log(BF_{10})$

Tests
- Student
- Mann-Whitney
  - No. samples 1000

Additional Statistics
- Descriptives

Plots
- Prior and posterior
  - Additional info
  - Credible interval 95.0 %
- Bayes factor robustness check
  - Additional info
- Sequential analysis
  - Robustness check
- Descriptives
  - Credible interval 95.0 %

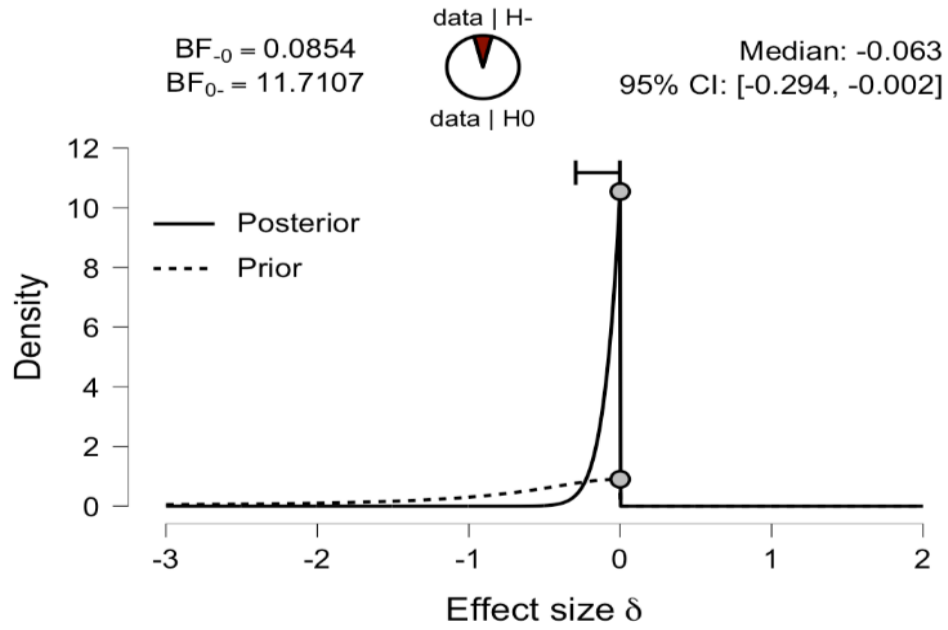
Missing Values
- Exclude cases per dependent variable
- Exclude cases listwise

Repeatability
- Set seed: 1

Inferential Plots

CriticalRecall

Prior and Posterior



Bayes Factor Robustness Check

- max BF_{-0}: 0.968 at r = 5e-04
- user prior: BF_{-0} = 0.08539
- wide prior: BF_{-0} = 0.06071
- ultrawide prior: BF_{-0} = 0.04368

配对样本t检验

Moon and Aggression*

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor

Bayesian Paired Samples T-Test

Moon
Other

Variable Pairs: Moon | Other

Alt. Hypothesis
- Measure 1 ≠ Measure 2
- Measure 1 > Measure 2
- Measure 1 < Measure 2

Plots
- Prior and posterior
  - Additional info
  - Credible interval 95.0 %
- Bayes factor robustness check
  - Additional info
- Sequential analysis
  - Robustness check
- Descriptives
  - Credible interval 95.0 %
- Raincloud plots
- Raincloud difference plots
  - Horizontal display

Bayes Factor
- BF_{10}
- BF_{01}
- $Log(BF_{10})$

Tests
- Student
- Wilcoxon signed-rank

No. samples 1000

Additional Statistics
- Descriptives

Missing Values
- Exclude cases per dependent variable
- Exclude cases listwise

Prior

Moon and Aggression: Paired Samples T-Test

Description:

This data set, "Moon & Aggression", provides the number of disruptive behaviors by dementia patients during two different phases of the lunar cycle (Moore et al, 2012, p. 410). Each row corresponds to one participant.

Variables:
- **Moon** - The average number of disruptive behaviors during full moon days.
- **Other** - The average number of disruptive behaviors during other days.

This example JASP file demonstrates the use of paired samples *t*-test. Specifically, we will examine the adequacy of the null hypothesis which states that the average number of disruptive behaviors among patients with dementia does not differ between moon days and other days.

References:

Moore, D. S., McCabe, G. P., and Craig. B. A. (2012) *Introduction to the Practice of Statistics* (7th ed). New York: Freeman.

"These data were collected as part of a larger study of dementia patients conducted by Nancy Edwards and Alan Beck, Purdue University." (Moore et al, 2012, p. N-8).

Bayesian Paired Samples T-Test

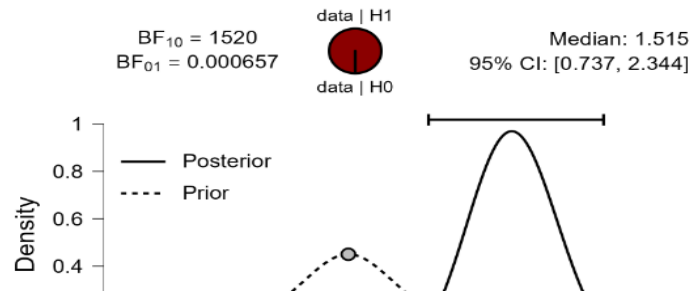
Bayesian Paired Samples T-Test

Measure 1		Measure 2	BF_{10}	error %
Moon	-	Other	1521.058	3.523e−7

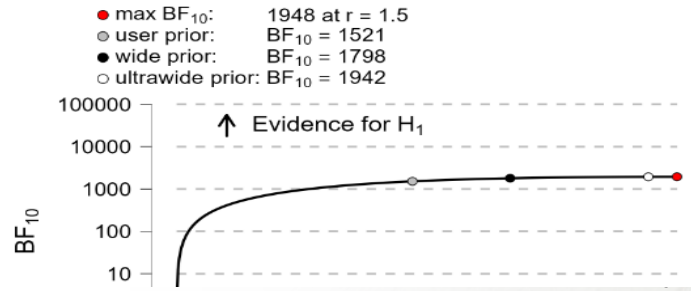
Inferential Plots

Moon - Other

Prior and Posterior



Bayes Factor Robustness Check



单样本t检验

Weight Gain*

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor

▶ **Descriptive Statistics**

▶ **One Sample T-Test**

▼ **Bayesian One Sample T-Test**

Weight Before
Weight After

Variables: Difference

Test value: 12

Alt. Hypothesis
- ≠ Test value
- > Test value
- < Test value

Bayes Factor
- BF_{10}
- BF_{01}
- Log(BF_{10})

Tests
- Student
- Wilcoxon signed-rank
  - No. samples 1000

Missing Values
- Exclude cases per dependent variable
- Exclude cases listwise

Plots
- Prior and posterior
  - Additional info
  - Credible interval 95.0 %
- Bayes factor robustness check
  - Additional info
- Sequential analysis
  - Robustness check
- Descriptives
  - Credible interval 95.0 %
- Raincloud plots
  - Horizontal display

Additional Statistics
- Descriptives

▶ Prior

Test of Normality (Shapiro-Wilk)

	W	p
Difference	0.938	0.325

Note. Significant results suggest a deviation from normality.

Bayesian One Sample T-Test ▼

Bayesian One Sample T-Test

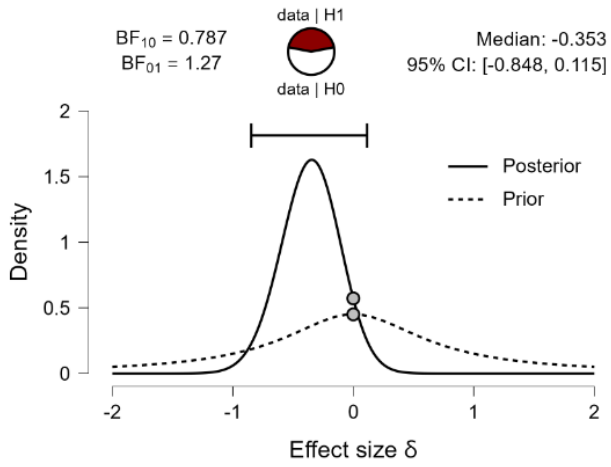
	BF_{10}	error %
Difference	0.787	0.022

Note. For all tests, the alternative hypothesis specifies that the population mean differs from 12.

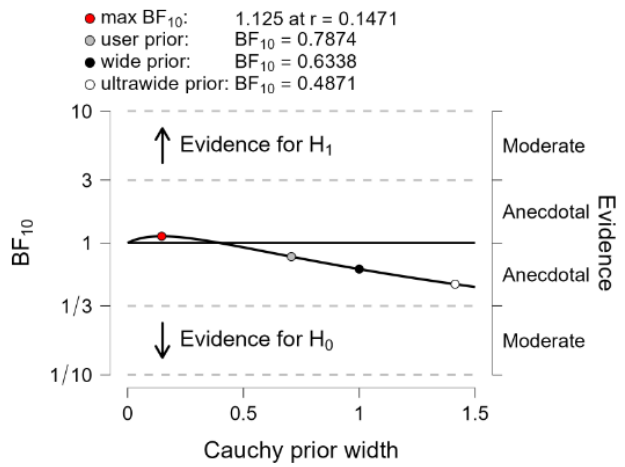
Inferential Plots ▼

Difference

Prior and Posterior



Bayes Factor Robustness Check



方差分析

Beer Goggles*

File | Common | +

Descriptives | T-Tests | ANOVA | Regression | Frequencies | Factor

Dependent Variable: Attractiveness

Fixed Factors: Alcohol, FaceType

Random Factors:

OK

Bayes Factor
- BF_{10}
- BF_{01}
- $Log(BF_{10})$

Order
- Compare to null model
- Compare to best model

Output
- Effects
  - Across all models
  - Across matched models
- Descriptives

Model

Post Hoc Tests

Descriptives Plots

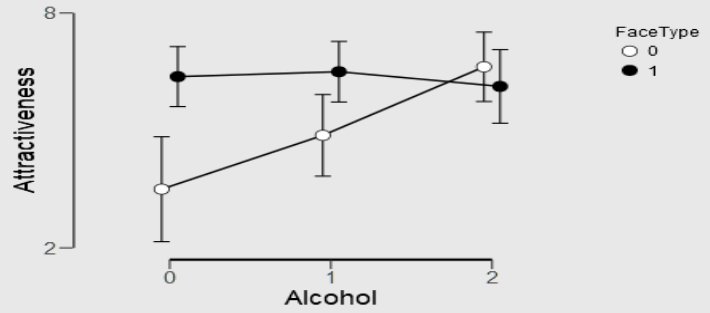
Advanced Options

Level of FaceType	Sum of Squares	df	Mean Square	F	p
0	39.250	2	19.625	14.335	< .001
1	0.583	2	0.292	0.213	0.809

Simple effects analysis reveals a significant effect of alcohol when rating unattractive faces; however, the null hypothesis cannot be rejected for participants rating attractive faces.

Descriptives

Descriptives Plot



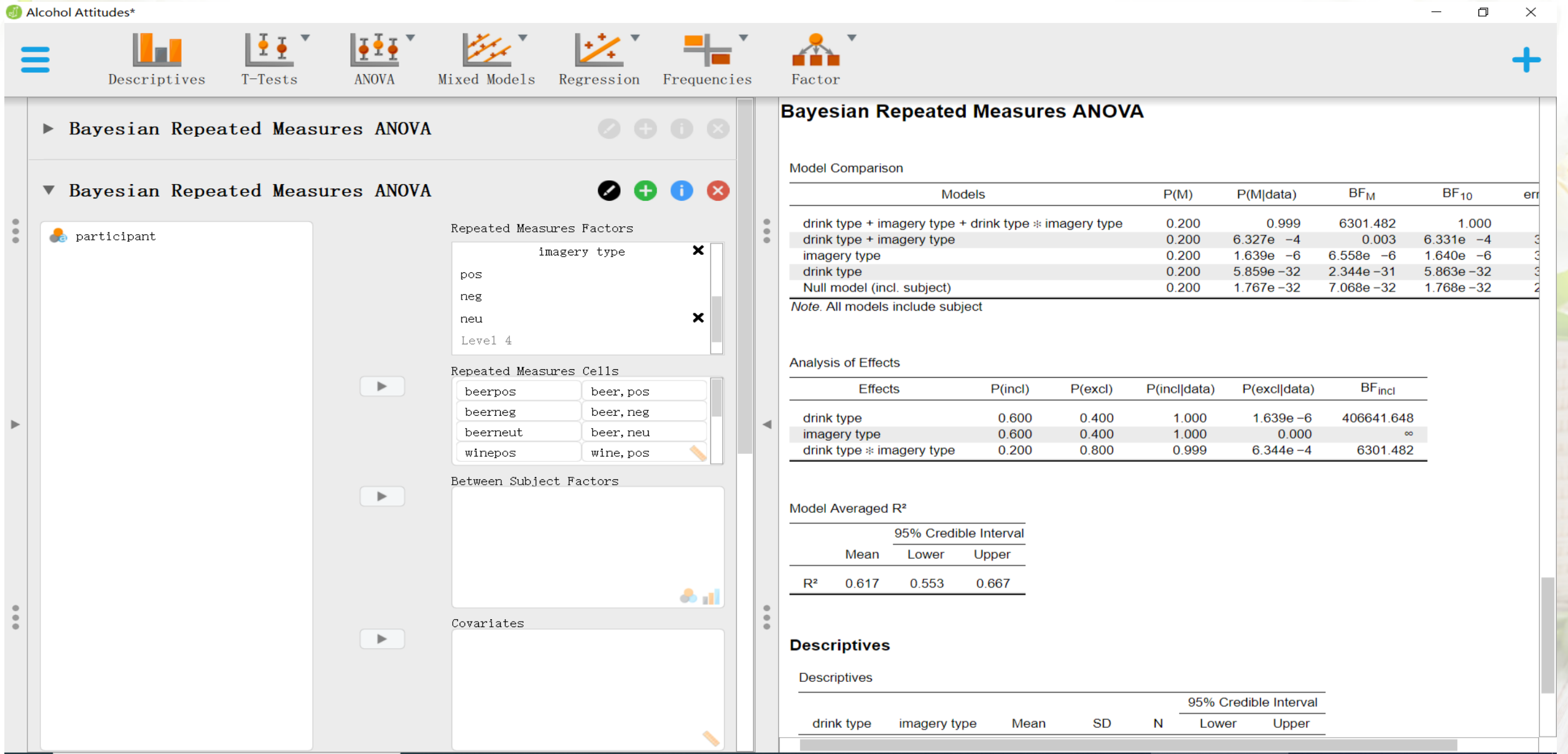
The overall pattern of observed means suggests that ratings of unattractive faces become more favorable when participants are under the influence of alcohol. There is no clear indication that ratings of attractive faces change as a result of alcohol consumption.

Bayesian ANOVA

Model Comparison - Attractiveness

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model	0.200	5.668e -4	0.002	1.000	
Alcohol	0.200	0.001	0.004	1.960	0.007
FaceType	0.200	0.008	0.032	13.906	8.759e −5
Alcohol + FaceType	0.200	0.027	0.110	47.208	0.753
Alcohol + FaceType + Alcohol ✻ FaceType	0.200	0.964	106.137	1700.142	1.670

重复测量方差分析


Alcohol Attitudes*
Descriptives
T-Tests
ANOVA
Mixed Models
Regression
Frequencies
Factor
Bayesian Repeated Measures ANOVA
Bayesian Repeated Measures ANOVA
participant
Repeated Measures Factors
imagery type
pos
neg
neu
Level 4
Repeated Measures Cells
beerpos
beer, pos
beerneg
beer, neg
beerneut
beer, neu
winepos
wine, pos
Between Subject Factors
Covariates
Bayesian Repeated Measures ANOVA
Model Comparison
Models
P(M)
P(M|data)
BF_M
BF_10
drink type + imagery type + drink type ✻ imagery type
0.200
0.999
6301.482
1.000
drink type + imagery type
0.200
6.327e −4
0.003
6.331e −4
imagery type
0.200
1.639e −6
6.558e −6
1.640e −6
drink type
0.200
5.859e −32
2.344e −31
5.863e −32
Null model (incl. subject)
0.200
1.767e −32
7.068e −32
1.768e −32
Note. All models include subject
Analysis of Effects
Effects
P(incl)
P(excl)
P(incl|data)
P(excl|data)
BF_incl
drink type
0.600
0.400
1.000
1.639e −6
406641.648
imagery type
0.600
0.400
1.000
0.000
∞
drink type ✻ imagery type
0.200
0.800
0.999
6.344e −4
6301.482
Model Averaged R²
95% Credible Interval
Mean
Lower
Upper
R²
0.617
0.553
0.667
Descriptives
Descriptives
drink type
imagery type
Mean
SD
N
95% Credible Interval
Lower
Upper

相关分析

Auction*

File | Common | +

Descriptives | T-Tests | ANOVA | Regression | Frequencies | Factor

OK

Age
Bidders
Price

Correlation Coefficients

- [x] Pearson's rho
- [ ] Kendall's tau-b

Hypothesis

- (•) Correlated
- ( ) Correlated positively
- ( ) Correlated negatively

Bayes Factor

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

- [x] Report Bayes factors
- [x] Flag supported correlations
- [x] Credible intervals

Plots

- [x] Correlation matrix
  - [x] Densities for variables
  - [x] Posteriors under H_1

Stretched beta prior width: 1

▶ Options

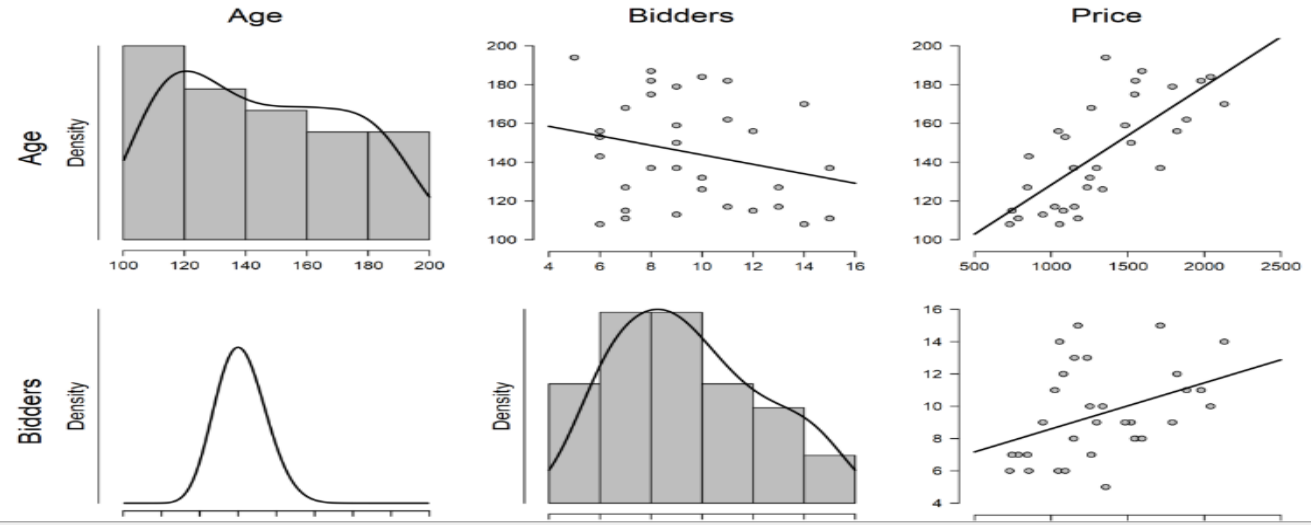
Bayesian Correlation Matrix

Bayesian Pearson Correlations

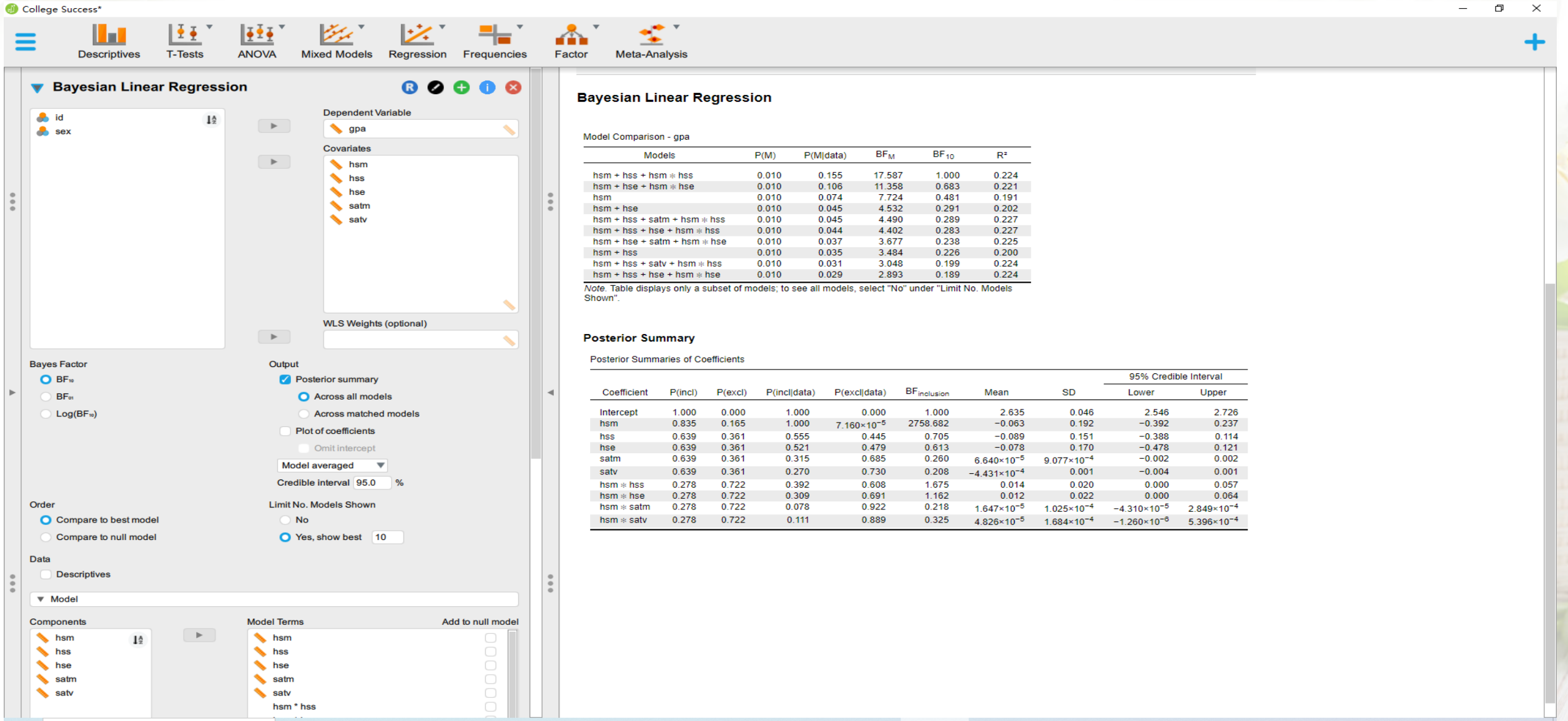
		Age	Bidders	Price
Age	Pearson's r	—		
	BF_{10}	—		
	Upper 95% CI	—		
	Lower 95% CI	—		
Bidders	Pearson's r	−0.254	—	
	BF_{10}	0.563	—	
	Upper 95% CI	0.101	—	
	Lower 95% CI	−0.534	—	
Price	Pearson's r	0.730***	0.395	—
	BF_{10}	10171.824	2.402	—
	Upper 95% CI	0.851	0.635	—
	Lower 95% CI	0.485	0.047	—

* $BF_{10} > 10$, ** $BF_{10} > 30$, *** $BF_{10} > 100$

Correlation Plot



回归分析


College Success*
Descriptives
T-Tests
ANOVA
Mixed Models
Regression
Frequencies
Factor
Meta-Analysis
Bayesian Linear Regression
id
sex
Dependent Variable
gpa
Covariates
hsm
hss
hse
satm
satv
WLS Weights (optional)
Bayes Factor
BF10
BF01
Log(BF10)
Output
Posterior summary
Across all models
Across matched models
Plot of coefficients
Omit intercept
Model averaged
Credible interval 95.0 %
Order
Compare to best model
Compare to null model
Limit No. Models Shown
No
Yes, show best 10
Data
Descriptives
Model
Components
hsm
hss
hse
satm
satv
Model Terms
Add to null model
hsm
hss
hse
satm
satv
hsm * hss
Bayesian Linear Regression
Model Comparison - gpa
Models | P(M) | P(M|data) | BFM | BF10 | R²
hsm + hss + hsm ✻ hss | 0.010 | 0.155 | 17.587 | 1.000 | 0.224
hsm + hse + hsm ✻ hse | 0.010 | 0.106 | 11.358 | 0.683 | 0.221
hsm | 0.010 | 0.074 | 7.724 | 0.481 | 0.191
hsm + hse | 0.010 | 0.045 | 4.532 | 0.291 | 0.202
hsm + hss + satm + hsm ✻ hss | 0.010 | 0.045 | 4.490 | 0.289 | 0.227
hsm + hss + hse + hsm ✻ hss | 0.010 | 0.044 | 4.402 | 0.283 | 0.227
hsm + hse + satm + hsm ✻ hse | 0.010 | 0.037 | 3.677 | 0.238 | 0.225
hsm + hss | 0.010 | 0.035 | 3.484 | 0.226 | 0.200
hsm + hss + satv + hsm ✻ hss | 0.010 | 0.031 | 3.048 | 0.199 | 0.224
hsm + hss + hse + hsm ✻ hse | 0.010 | 0.029 | 2.893 | 0.189 | 0.224
Note. Table displays only a subset of models; to see all models, select "No" under "Limit No. Models Shown".
Posterior Summary
Posterior Summaries of Coefficients
Coefficient | P(incl) | P(excl) | P(incl|data) | P(excl|data) | BFinclusion | Mean | SD | 95% Credible Interval Lower | 95% Credible Interval Upper
Intercept | 1.000 | 0.000 | 1.000 | 0.000 | 1.000 | 2.635 | 0.046 | 2.546 | 2.726
hsm | 0.835 | 0.165 | 1.000 | 7.160×10−5 | 2758.682 | −0.063 | 0.192 | −0.392 | 0.237
hss | 0.639 | 0.361 | 0.555 | 0.445 | 0.705 | −0.089 | 0.151 | −0.388 | 0.114
hse | 0.639 | 0.361 | 0.521 | 0.479 | 0.613 | −0.078 | 0.170 | −0.478 | 0.121
satm | 0.639 | 0.361 | 0.315 | 0.685 | 0.260 | 6.640×10−5 | 9.077×10−4 | −0.002 | 0.002
satv | 0.639 | 0.361 | 0.270 | 0.730 | 0.208 | −4.431×10−4 | 0.001 | −0.004 | 0.001
hsm ✻ hss | 0.278 | 0.722 | 0.392 | 0.608 | 1.675 | 0.014 | 0.020 | 0.000 | 0.057
hsm ✻ hse | 0.278 | 0.722 | 0.309 | 0.691 | 1.162 | 0.012 | 0.022 | 0.000 | 0.064
hsm ✻ satm | 0.278 | 0.722 | 0.078 | 0.922 | 0.218 | 1.647×10−5 | 1.025×10−4 | −4.310×10−5 | 2.849×10−4
hsm ✻ satv | 0.278 | 0.722 | 0.111 | 0.889 | 0.325 | 4.826×10−5 | 1.684×10−4 | −1.260×10−6 | 5.396×10−4

二项检验

Hungry Zombies

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor | Meta-Analysis

Bayesian Binomial Test

Bayesian Binomial Test

Outcome

Test value: 1

Alt. Hypothesis

Direction

- ≠ Test value
- > Test value
- < Test value

Prior

Beta prior: parameter a 2

Beta prior: parameter b 1

Bayes Factor

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

Plots

- Prior and posterior
  - Additional info
- Sequential analysis
- Descriptive plots

Credible interval 95.0 %

Bayesian Binomial Test

Bayesian Binomial Test

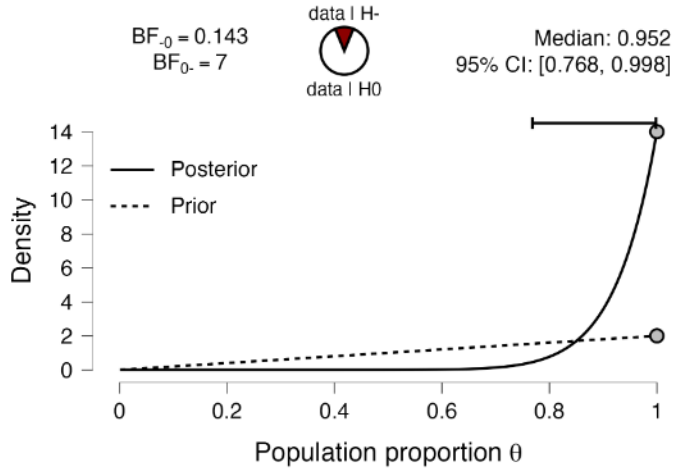
	Level	Counts	Total	Proportion	BF_{0-}
Outcome	Hungry	12	12	1.000	7.000

Note. For all tests, the alternative hypothesis specifies that the proportion is less than 1. The shape of the prior distribution under the alternative hypothesis is specified by Beta(2, 1).

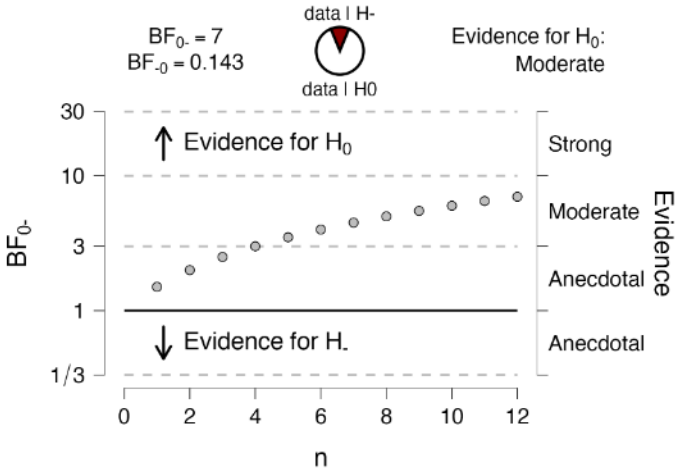
Inferential Plots

Outcome - Hungry

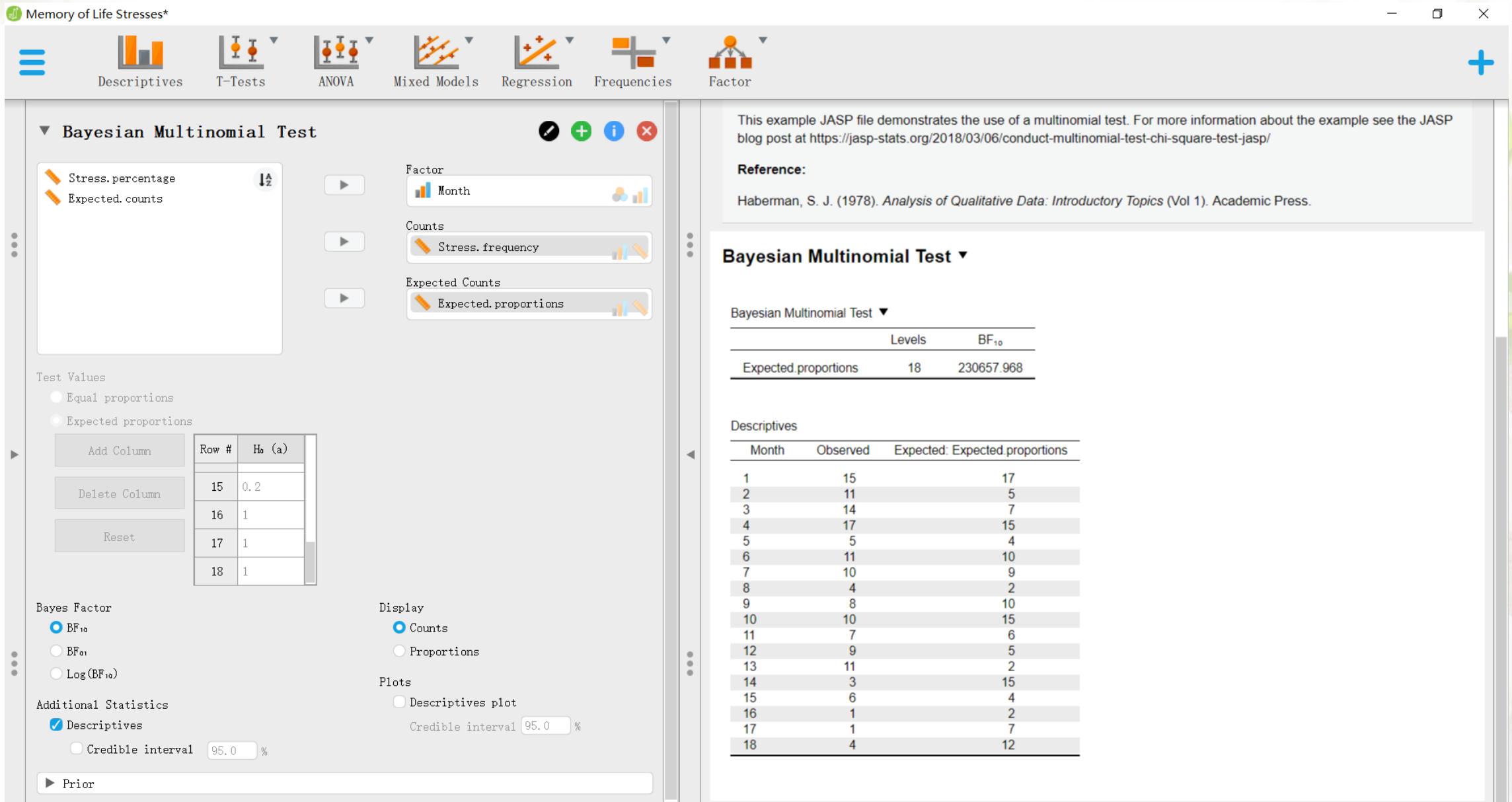
Prior and Posterior



Sequential Analysis



多项检验


Memory of Life Stresses*
Descriptives
T-Tests
ANOVA
Mixed Models
Regression
Frequencies
Factor
Bayesian Multinomial Test
Stress.percentage
Expected.counts
Factor
Month
Counts
Stress.frequency
Expected Counts
Expected.proportions
Test Values
Equal proportions
Expected proportions
Add Column
Delete Column
Reset
Row #
Hₐ (a)
15 0.2
16 1
17 1
18 1
Bayes Factor
BF₁₀
BF₀₁
Log(BF₁₀)
Additional Statistics
Descriptives
Credible interval 95.0 %
Display
Counts
Proportions
Plots
Descriptives plot
Credible interval 95.0 %
Prior
This example JASP file demonstrates the use of a multinomial test. For more information about the example see the JASP blog post at https://jasp-stats.org/2018/03/06/conduct-multinomial-test-chi-square-test-jasp/
Reference:
Haberman, S. J. (1978). Analysis of Qualitative Data: Introductory Topics (Vol 1). Academic Press.
Bayesian Multinomial Test
Bayesian Multinomial Test
Levels
BF₁₀
Expected.proportions 18 230657.968
Descriptives
Month
Observed
Expected: Expected.proportions
1 15 17
2 11 5
3 14 7
4 17 15
5 5 4
6 11 10
7 10 9
8 4 2
9 8 10
10 10 15
11 7 6
12 9 5
13 11 2
14 3 15
15 6 4
16 1 2
17 1 7
18 4 12

列联表分析

Listerism

Descriptives | T-Tests | ANOVA | Mixed Models | Regression | Frequencies | Factor

Bayesian Contingency Tables

Rows: Method

Columns: Outcome

Counts: Count

Layers

▼ Statistics

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

Additional Statistics
- Log odds ratio (2x2 only)
  - Credible interval 95.0 %

Alt. Hypothesis
- Group one ≠ Group two
- Group one > Group two
- Group one < Group two

Plots
- Log odds ratio (2x2 only)
  - Additional info

Bayesian Contingency Tables

Contingency Tables

Method	Outcome: Did Well	Outcome: Blood Poisoning	Total
Lister	7	3	10
Standard	9	5	14
Total	16	8	24

For the test of this 2x2 table, the selected analysis option "independent multinomial, rows fixed" simplifies to a comparison between the recovery proportions for Lister's method versus the Standard method (Jeffreys, 1935). In the input panel, the hypothesis is specified as "Group one > Group two", which means the test is one-sided. The resulting Bayes factor in favor of H1 equals 0.552, which means that data are 1/0.552 = 1.8 times more likely under H0. In MacAlister's terminology, "we may wager nearly 2 to 1 that the difference in the results is due to mere chance".

Bayesian Contingency Tables Tests

	Value
BF_{+0} Independent multinomial	0.562
N	24

Note. For all tests, the alternative hypothesis specifies that group *Lister* is greater than *Standard*.

Log Odds Ratio Plots

Method - Outcome