Bayesian Statistics and Hierarchical Bayesian Modeling for Psychological Science

Lecture 05

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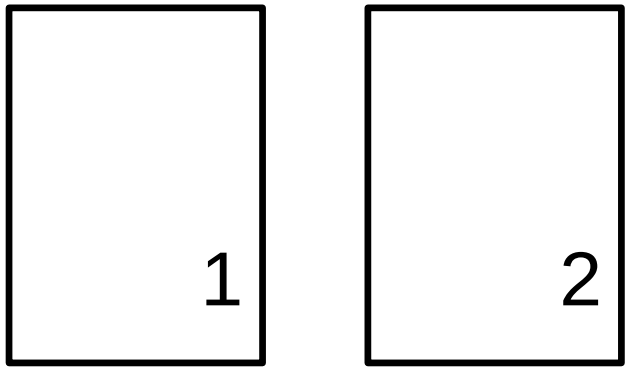
https://github.com/lei-zhang/BayesCog_Wien

universität wien
Fakultät für Psychologie

Review of a paper?

bioRxiv beta
THE PREPRINT SERVER FOR BIOLOGY



- decision-making
- cognitive modeling
- no fMRI
- equal length/difficulty

After L05	students 1:5	students 6:9
After L11	students 6:9	students 1:5

https://github.com/lei-zhang/BayesCog_Wien/tree/master/review_a_paper

Review of a paper?

Paper01

CATECHOLAMINE CHALLENGE UNCOVERS DISTINCT MECHANISMS FOR DIRECT VERSUS INDIRECT, BUT NOT SOCIAL VERSUS NON-SOCIAL, LEARNING

1. a01406697
2. a01447859
3. a11905886
4. a01548241
5. a01642221

Paper02

Can model-free reinforcement learning operate over information stored in working-memory?

6. a01448489
7. a01548241
8. a11921768
9. a01448749

https://github.com/lei-zhang/BayesCog_Wien/tree/master/review_a_paper

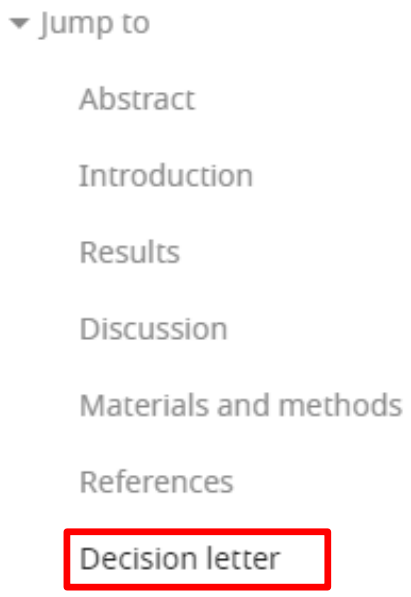
How to review a paper?

- Suppose you are invited by a journal editor to review a paper
- Of course, you have to read it☺, carefully and critically
- Then write a review report to the editor
  - (1) Make a summary. What is this paper about? What was done? What was the conclusion?
  - (2) List your concerns. Is the design appropriate? Are the analyses sound? Do their data support the conclusion? What can be done better?
- For this course:
  - be independent: okay to discuss HOW to review, but do NOT discuss WHAT to review

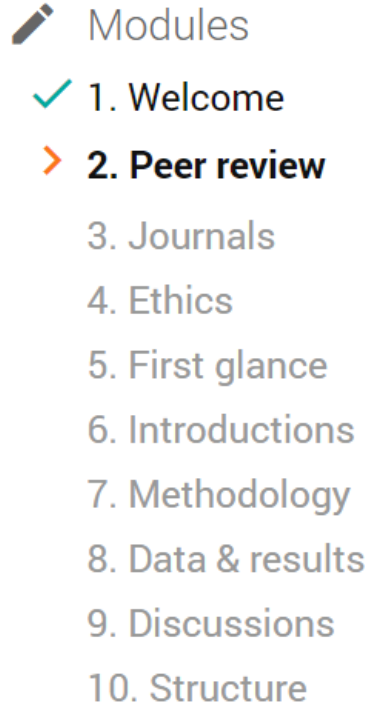
https://github.com/lei-zhang/BayesCog_Wien/tree/master/review_a_paper

Where to learn to review a paper?

- Publicly available review reports:
  - Nature Communications
  - eLife



- Structured online course
  - Publons Academy



https://github.com/lei-zhang/BayesCog_Wien/tree/master/review_a_paper

Review in action

"Title of the paper"

Summary of the paper

In this paper xx et al., investigated xxx…

Strength of the paper

[theoretical contribution, experimental design, methodological endeavor, etc.]

Major concerns

[lacking literatures, inappropriate analyses, conclusion cannot be directly supported by the results etc.]

Minor concerns

[typo, imprecise statistics (e.g., missing degrees of freedom), grammar mistakes, etc.]

- up to 3 pages (12pt, 1.5 space)
- send it via email to me
- New Due!: Sunday 24.11.2019

https://github.com/lei-zhang/BayesCog_Wien/tree/master/review_a_paper

Bayesian warm-up?

Basic stats

```
> as.matrix(acc_mean, 10, 1)
          [,1]
 [1,] 0.8076923
 [2,] 0.7125000
 [3,] 0.6875000
 [4,] 0.6493506
 [5,] 0.7750000
 [6,] 0.7250000
 [7,] 0.7662338
 [8,] 0.8000000
 [9,] 0.7500000
[10,] 0.6750000
```

```
mean(acc_mean)
sd(acc_mean)
sem(acc_mean)

t.test(acc_mean, mu = 0.5) # one sample t-test

        One Sample t-test

data:  acc_mean
t = 13.788, df = 9, p-value = 2.34e-07
alternative hypothesis: true mean is not equal to 0.5
95 percent confidence interval:
 0.6962988 0.7733565
sample estimates:
mean of x
0.7348277
```

Basic correlation

```
load('_data/RL_descriptive.RData')
descriptive$acc = acc_mean
df = descriptive

cor.test(df$IQ, df$acc)

        Pearson's product-moment correlation

data:  df$IQ and df$acc
t = 4.8347, df = 8, p-value = 0.001297
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.5114810 0.9671586
sample estimates:
      cor
0.8631401
```

```
> descriptive
   subjID        IQ      Age    acc
1       1 123.98691 31.07218 0.8125
2       2  87.63187 30.13800 0.7125
3       3  89.39930 23.44219 0.6875
4       4  84.34607 27.44848 0.6500
5       5 134.72208 23.30624 0.7750
6       6  84.60797 25.67858 0.7250
7       7 111.10238 24.36375 0.7750
8       8 117.89599 32.74026 0.8000
9       9  96.88233 22.80211 0.7500
10     10  76.01652 30.44258 0.6750
```

Exercise IV

```
…/01.R_basics/_scripts/R_basics.R
```

TASK:

Read in the descriptive data: _data/descriptive.RData

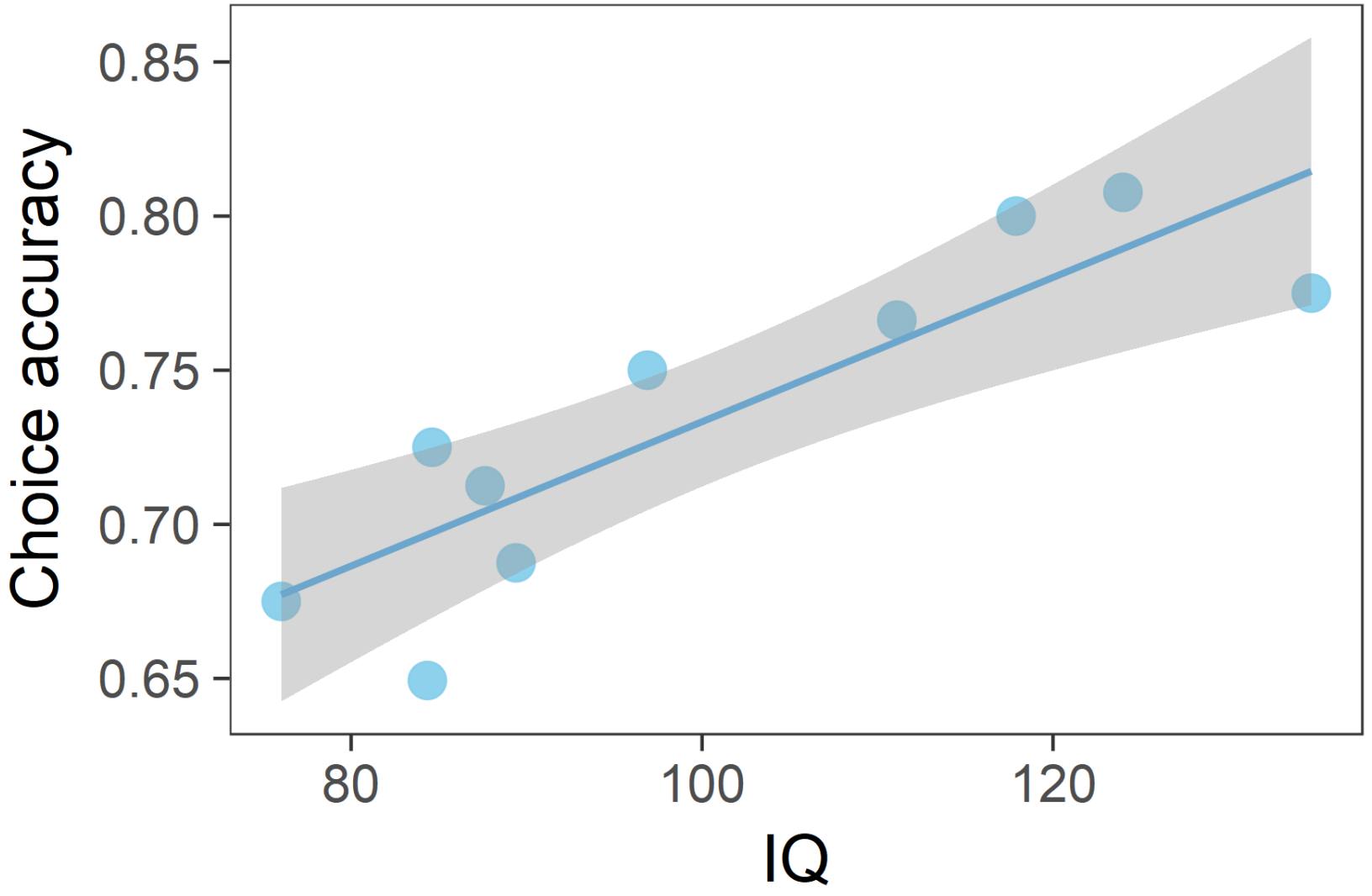
…include ‘acc_mean’ as a new column, and

…rename ‘descriptive’ as df.

Practice all the basic stats.

```
df$new_Col = new_Col
```

A simple linear regression



What is exactly the regression line in R?

$$\mu_i = \alpha + \beta x_i$$

$$y_i = \mu_i + \varepsilon$$

$0.8631^2 = 0.7131$

```
fit1 = lm(acc ~ IQ, data = df)
summary(fit1)

Call:
lm(formula = acc ~ IQ, data = df)

Residuals:
      Min        1Q    Median        3Q       Max
-0.047305 -0.016277  0.007562  0.022577  0.027731

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 0.499292   0.049565  10.073 8.04e-06 ***
IQ          0.002340   0.000484   4.835   0.0013 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02885 on 8 degrees of freedom
Multiple R-squared:  0.745,  Adjusted R-squared:  0.7131
F-statistic: 23.37 on 1 and 8 DF,  p-value: 0.001297
```

Exercise V

```
…/01.R_basics/_scripts/R_basics.R
```

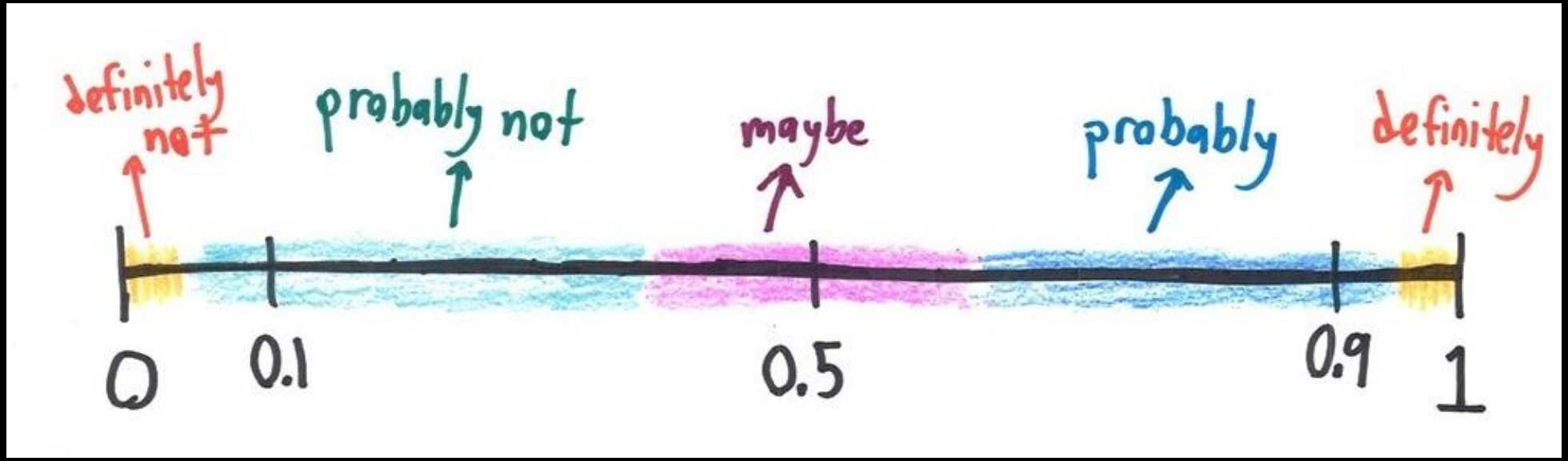
TASK:

Read and make sense of the ggplot functions,

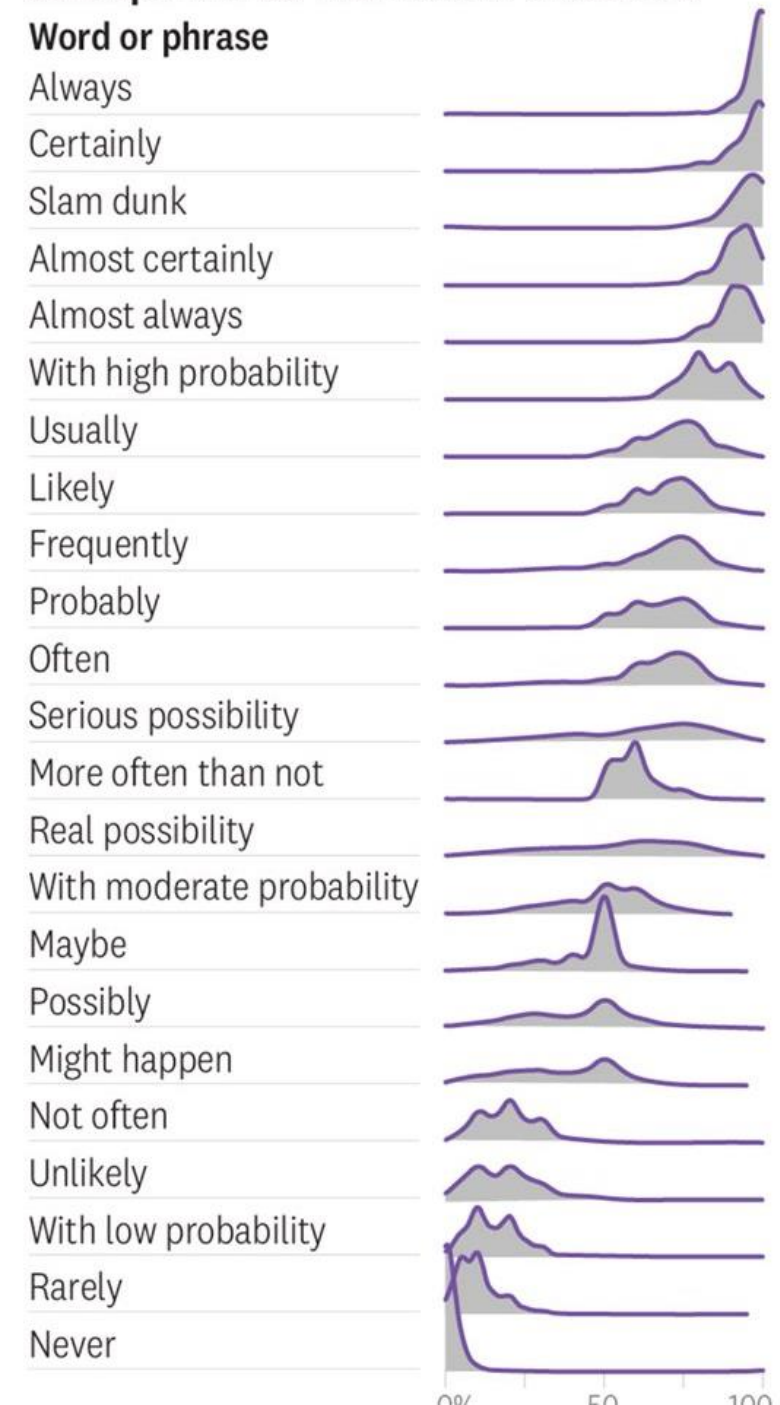
… experiment make some adjustments (color marker size etc.), and

… run the `lm(acc ~ IQ)`

BASICS OF PROBABILITY



to respondents' estimate of likelihood



Probability

cognitive model
statistics
computing

…assigning numbers to a set of possibilities

Properties (Kolmogorov, 1956)

- $p \in [0,1]$
- $\Sigma p = 1$

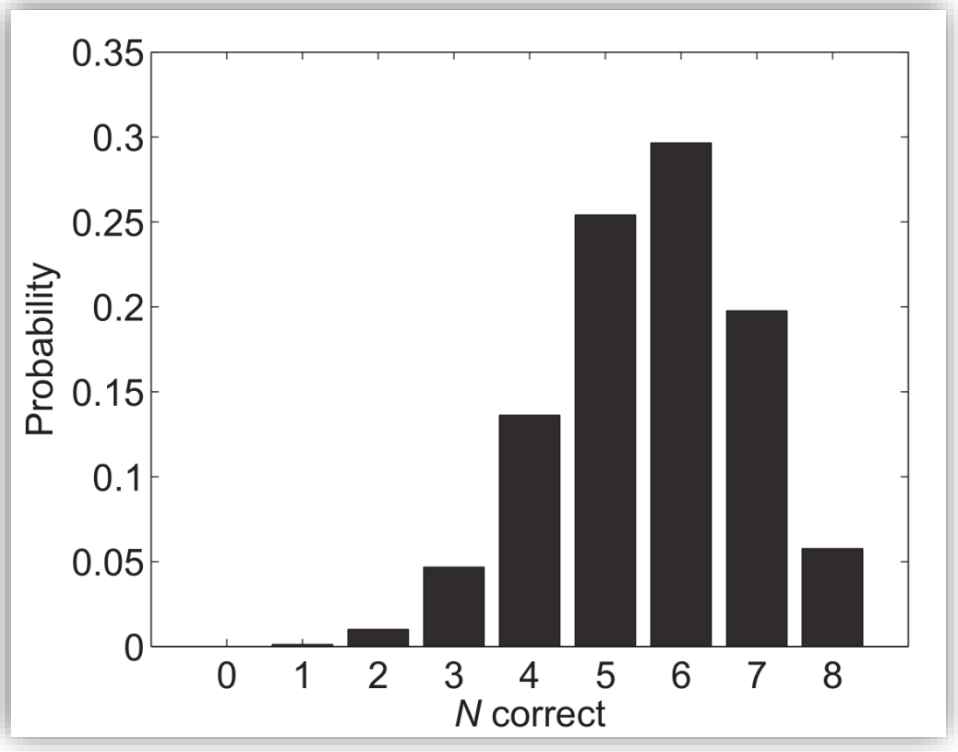
Probabilities are used to express uncertainty.

Probability Functions

cognitive model
statistics
computing

discrete events – we talk about mass

Run a test and record each student's correct responses



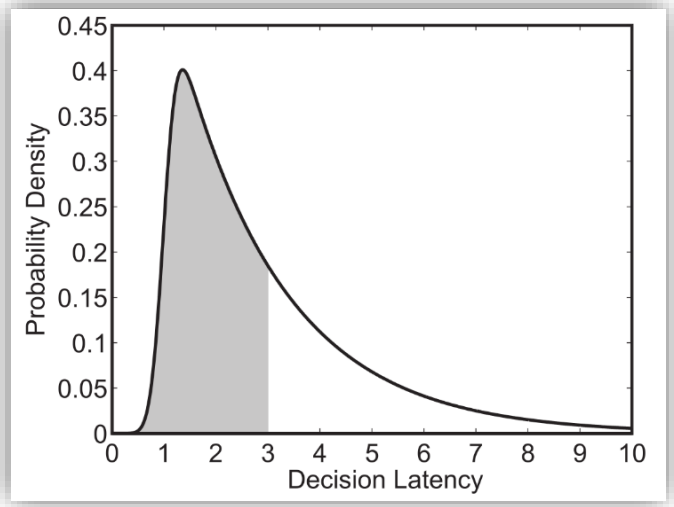
Lewandowsky & Farrell (2011)

Probability Functions

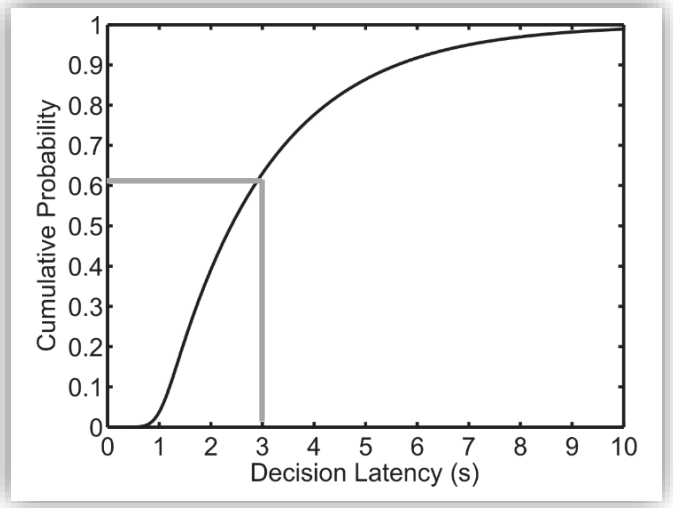
cognitive model
statistics
computing

continuous events – we talk about density

probability density function (PDF)



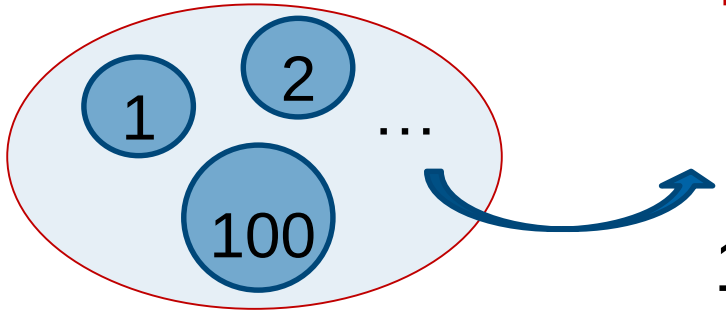
cumulative distribution function (CDF)



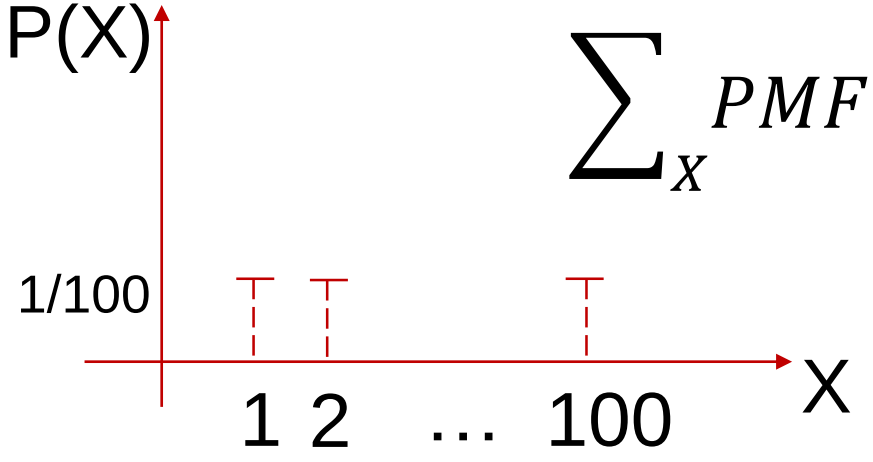
Lewandowsky & Farrell (2011)

Another example

Discrete



X	P(X)
1	1/100
2	1/100
…	…
100	1/100



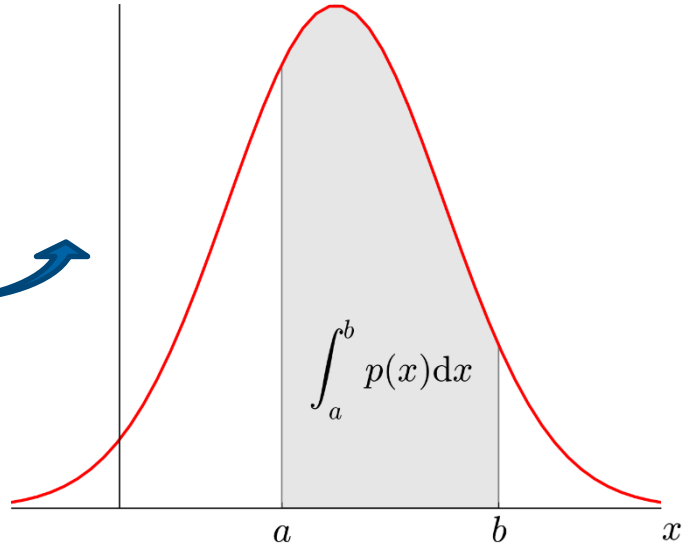
$$\sum_X PMF(X) = 1$$

Continuous

Height

X	P(X)
1.8 m	0

PDF



P given by the area

$$1.75 \leq X \leq 1.85$$

Playing with Probability Functions in R

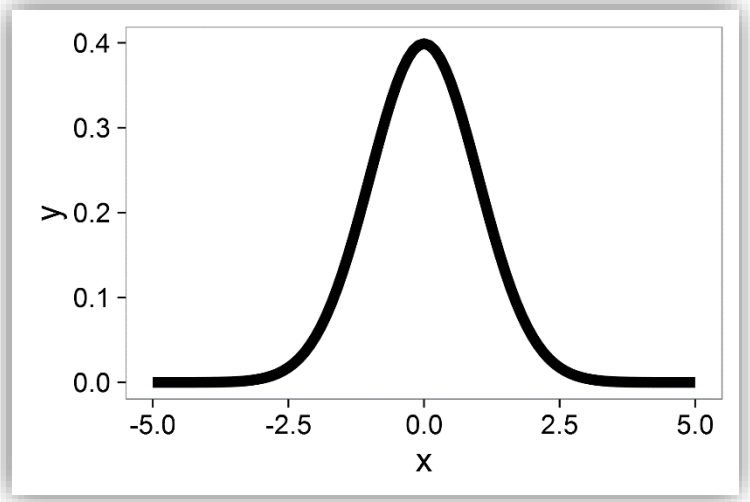
cognitive model
statistics
computing

```
dnorm() - PDF
pnorm() - CDF
qnorm() - quantile, inverse cdf
rnorm() - random number generator
```

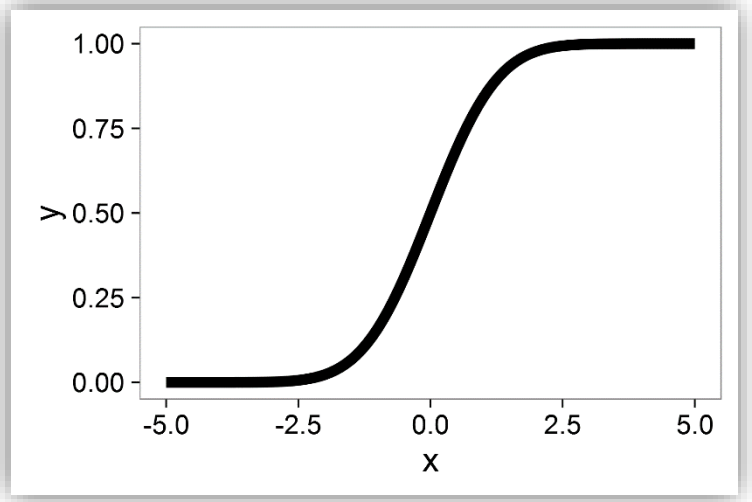
Example: Normal(0,1)

cognitive model
statistics
computing

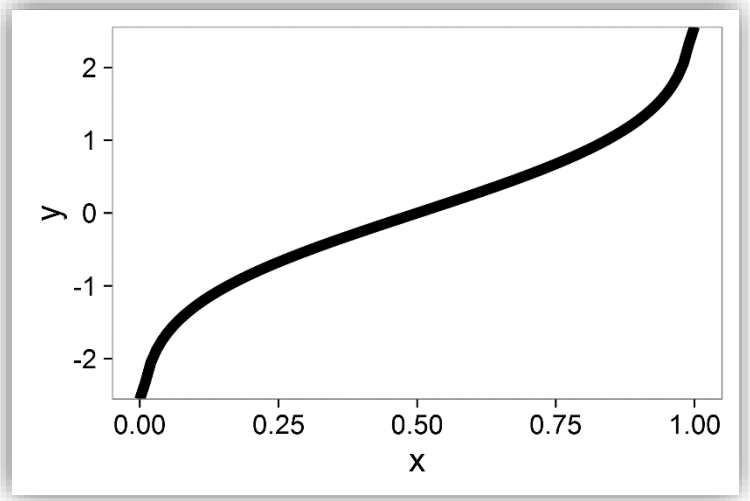
dnorm()



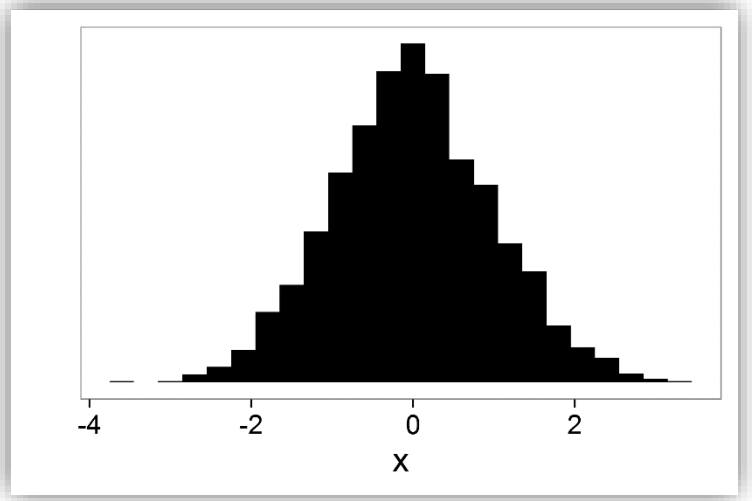
pnorm()



qnorm()



rnorm()



Joint Probability and Conditional Probability

cognitive model
statistics
computing

Joint Probability

$p(A, B) = p(B, A)$

- e.g., $p(\text{raining, cold})$: $p(\text{raining})$ AND $p(\text{cold})$

Conditional Probability

$p(A|B)$ – 'p of A given B' – event B is fixed, not uncertainty

$p(A,B) = p(A|B)p(B)$

- e.g., $p(\text{raining, cold}) = p(\text{raining}|\text{cold})p(\text{cold})$