SPM8 for Basic and Clinical Investigators

Study Design Principles

Study Design Principles

Averages and measures of dispersion

Using variance for hypothesis testing

One-factor between subjects designs

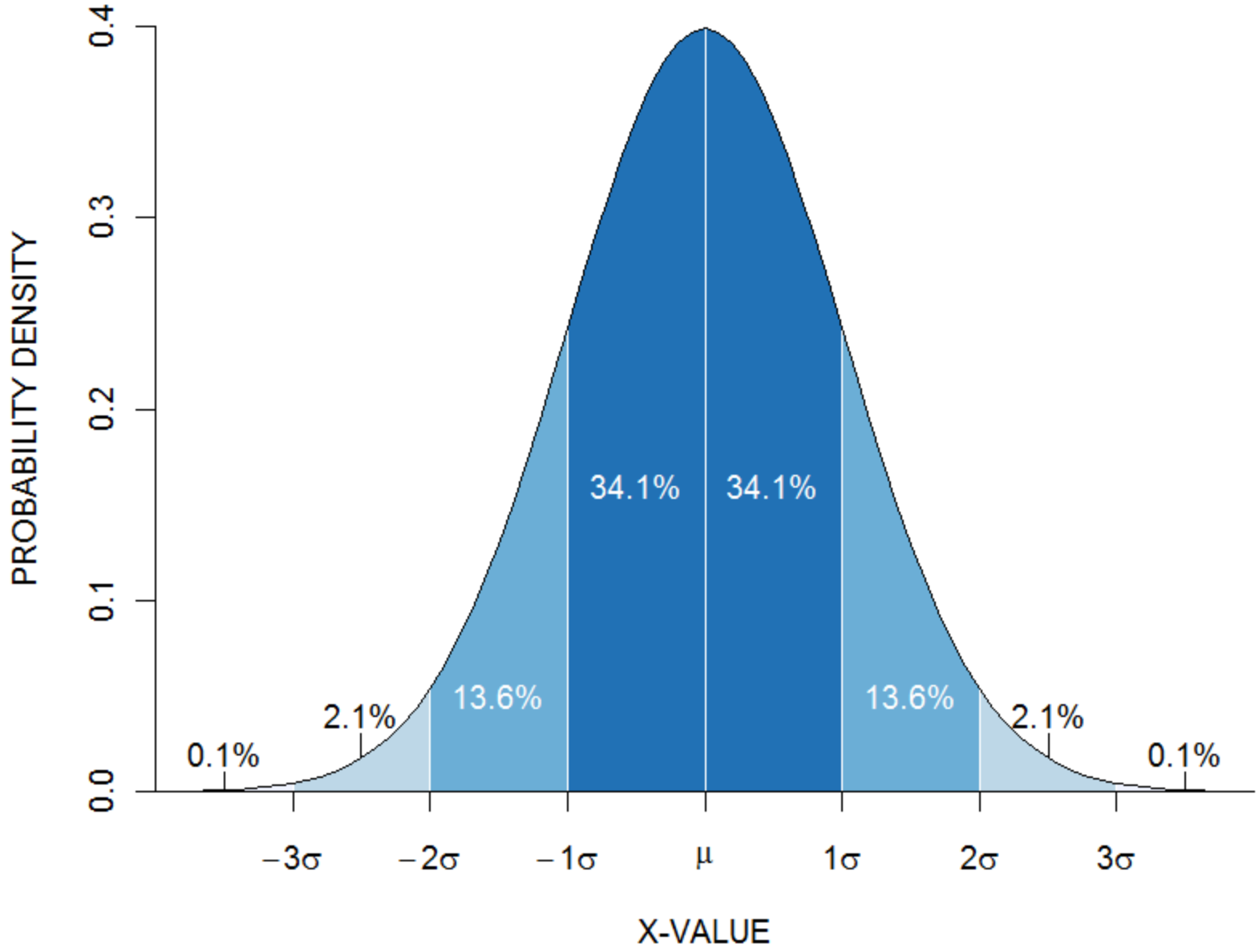
One-factor within subjects designs

Factorial designs and interactions

Two-factor mixed designs

Averages and measures of dispersion

- Variance
- Standard deviation
- Standard error
- Confidence interval


PROBABILITY DENSITY
0.0
0.1
0.2
0.3
0.4
34.1%
34.1%
13.6%
13.6%
2.1%
2.1%
0.1%
0.1%
−3σ
−2σ
−1σ
μ
1σ
2σ
3σ
X-VALUE

Variance

$$\text{VAR} = \frac{\sum (X - u)^2}{N}$$

where: X = value

u = sample mean

N = sample size

Standard deviation

$$SD = \sqrt{\frac{\sum (X - u)^2}{N}}$$

where: X = value

u = sample mean

N = sample size

Standard deviation

Unbiased SD = $\sqrt{\frac{\sum (X - u)^2}{N - 1}}$

where: X = value

u = sample mean

N = sample size

Standard error

SE = $SD/\sqrt{N}$

where: X = value

u = sample mean

N = sample size

Confidence interval

$$\text{CI} = u \pm t_{1-a/2} \frac{SD}{\sqrt{N}}$$

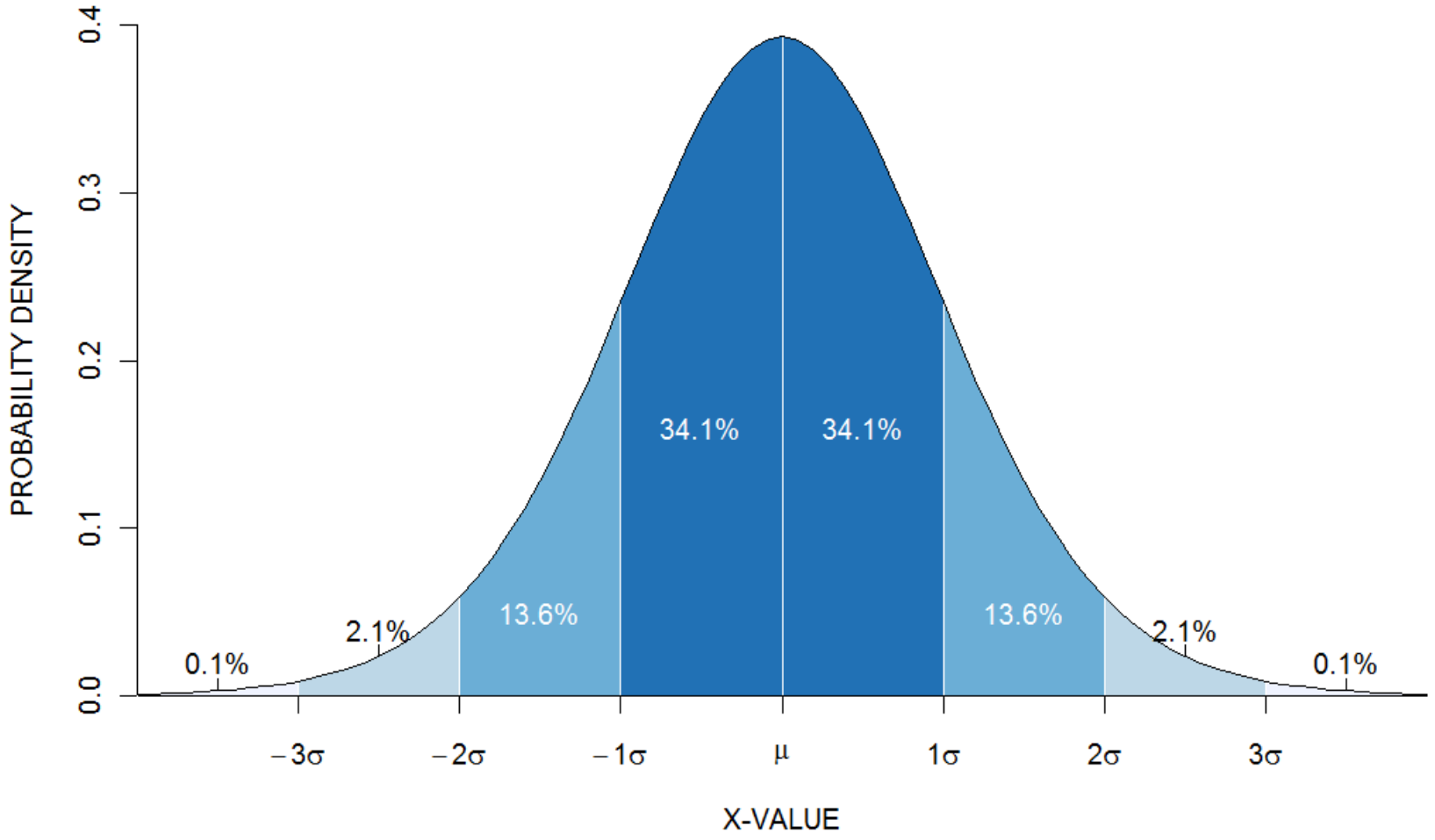
where: $t_{1-a/2}$ = *t* value for 100(1-a)% confidence

SD = standard deviation

u = sample mean

N = sample size

t distribution



Confidence interval

$$\text{CI} = u \pm t_{1-a/2} \frac{SD}{\sqrt{N}}$$

where: $t_{1-a/2}$ = *t* value for 100(1-a)% confidence

SD = standard deviation

u = sample mean

N = sample size

Descriptive statistics

$$\text{VAR} = \frac{\sum (X-u)^2}{N}$$

$$\text{SD} = \sqrt{\frac{\sum (X-u)^2}{N}}$$

$$\text{SE} = SD/\sqrt{N}$$

$$\text{CI} = u \pm t_{1-a/2} SD/\sqrt{N}$$

Using variance for hypothesis testing

- *t*-test limitations
- Analysis of Variance
- Sources of variability
- F ratio

One-factor between subjects designs

- ANOVA and the central limit theorem
- ANOVA assumptions
- Rogue data
- Interpreting the F test
- Planned comparisons
- Linear contrast analysis

One-factor between subjects designs

In one-factor between subjects designs the total variability is partitioned into between-group variability and within-group variability

One-factor within subjects designs

- Relative power compared to between designs
- Order effects
- Additional assumption for with subjects designs

One-factor within subjects designs

In one-factor within subjects designs the within group variability is partitioned into between subject variability and residual variability

Factorial designs and interactions

- Two factor designs
- Three factor designs
- Factorial design outcomes
  - No main effects
  - One main effect
  - Two main effects
  - Simple main effects
  - Interactions
- Planning factorial designs

Factorial designs and interactions

In a 2x2 between subjects designs the between group variability is partitioned into main effect and interaction variability

Two-factor mixed designs

- At least one between group and one within group factor
- Requires two error terms
  - between subjects main effect
  - within subjects main effect
- Selection of error term for simple main effects is controversial
  - pooled error terms

Two-factor mixed designs

- Common in clinical fMRI studies
- The effects of interest may be group by task interactions
- Three-factor designs can incorporate a treatment main effect
  - Take care to ensure adequate power to detect three-way interactions!

Sources

A Student's Guide to Analysis of Variance
Roberts and Russo (1999)

Introduction to Analysis of Variance
Turner and Thayer (2001)

Introducing ANOVA and ANCOVA: a GLM Approach
Rutherford (2001)

The Design of Experiments
Fisher(1935)

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