北京師範大學
BEIJING NORMAL UNIVERSITY

两因素方差分析 SPSS 实操

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Two-factor **completely randomized** experimental design

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Two-factor **mixed** experimental design

一、两因素完全随机实验设计

1. 两因素完全随机实验设计

研究者希望同时探讨文章**主题熟悉性（A）**和**文章的生字密度（B）**对**学生阅读理解（Y）**的影响。

文章熟悉性：被试间变量，儿童熟悉(a1)；儿童不熟悉（a2）

生字密度：被试间变量，5:1(b1)；10:1(b2)；20:1(b3)

- 2*3 的两因素被试间实验设计
- 6种处理水平的结合，每个被试接受一种处理水平的结合
- 24名5年级学生随机分为6组，每组阅读一种类型的文章，并测量阅读理解得分

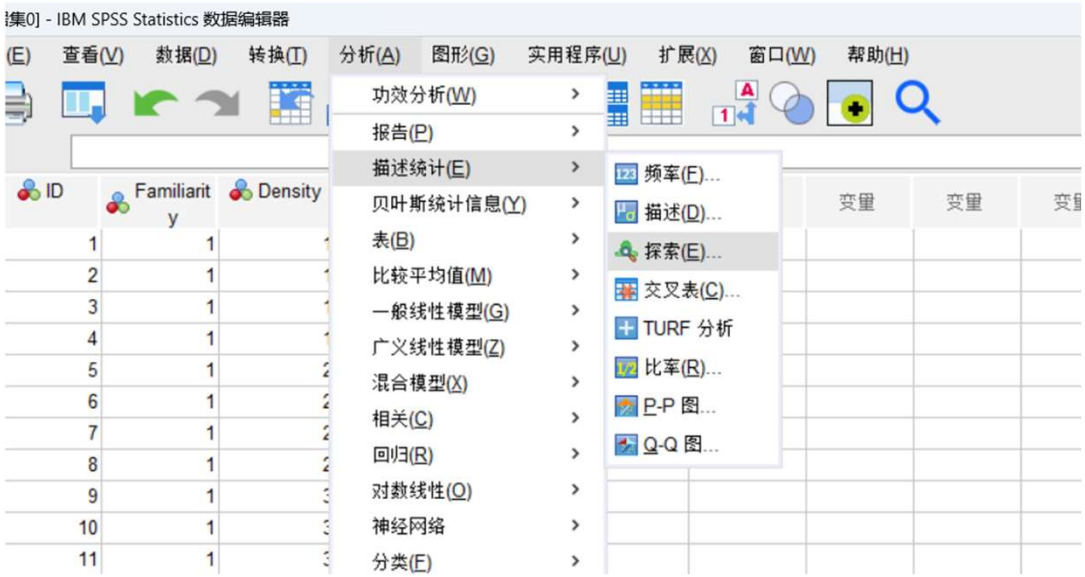
1. 两因素完全随机实验设计

数据录入

	名称	类型	宽度	小数位数	标签	值	缺失	列
1	ID	数字	8	0	被试编号	无	无	8
2	A	数字	8	0	主题熟悉度	{1, 熟悉}...	无	8
3	B	数字	8	0	生字密度	{1, 1：5}...	无	8
4	Y	数字	8	2	阅读理解	无	无	8
5								

	ID	A	B	Y
1	1	1	1	3.00
2	2	1	1	6.00
3	3	1	1	4.00
4	4	1	1	3.00
5	5	1	2	4.00
6	6	1	2	6.00
7	7	1	2	4.00
8	8	1	2	2.00
9	9	1	3	5.00
10	10	1	3	7.00
11	11	1	3	5.00
12	12	1	3	2.00
13	13	2	1	4.00
14	14	2	1	5.00
15	15	2	1	3.00
16	16	2	1	3.00
17	17	2	2	8.00
18	18	2	2	9.00
19	19	2	2	8.00
20	20	2	2	7.00
21	21	2	3	12.00
22	22	2	3	13.00
23	23	2	3	12.00
24	24	2	3	11.00

正态检验



Tests of Normality

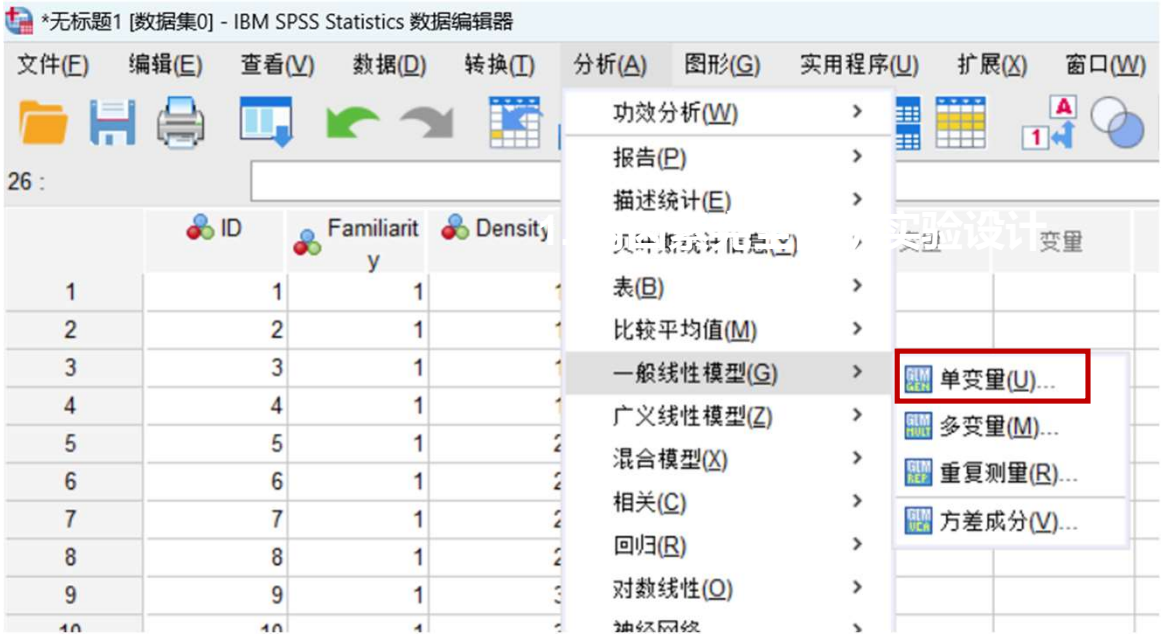
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
阅读理解	.170	24	.071	.902	24	.023

a. Lilliefors Significance Correction

略微偏离正态；

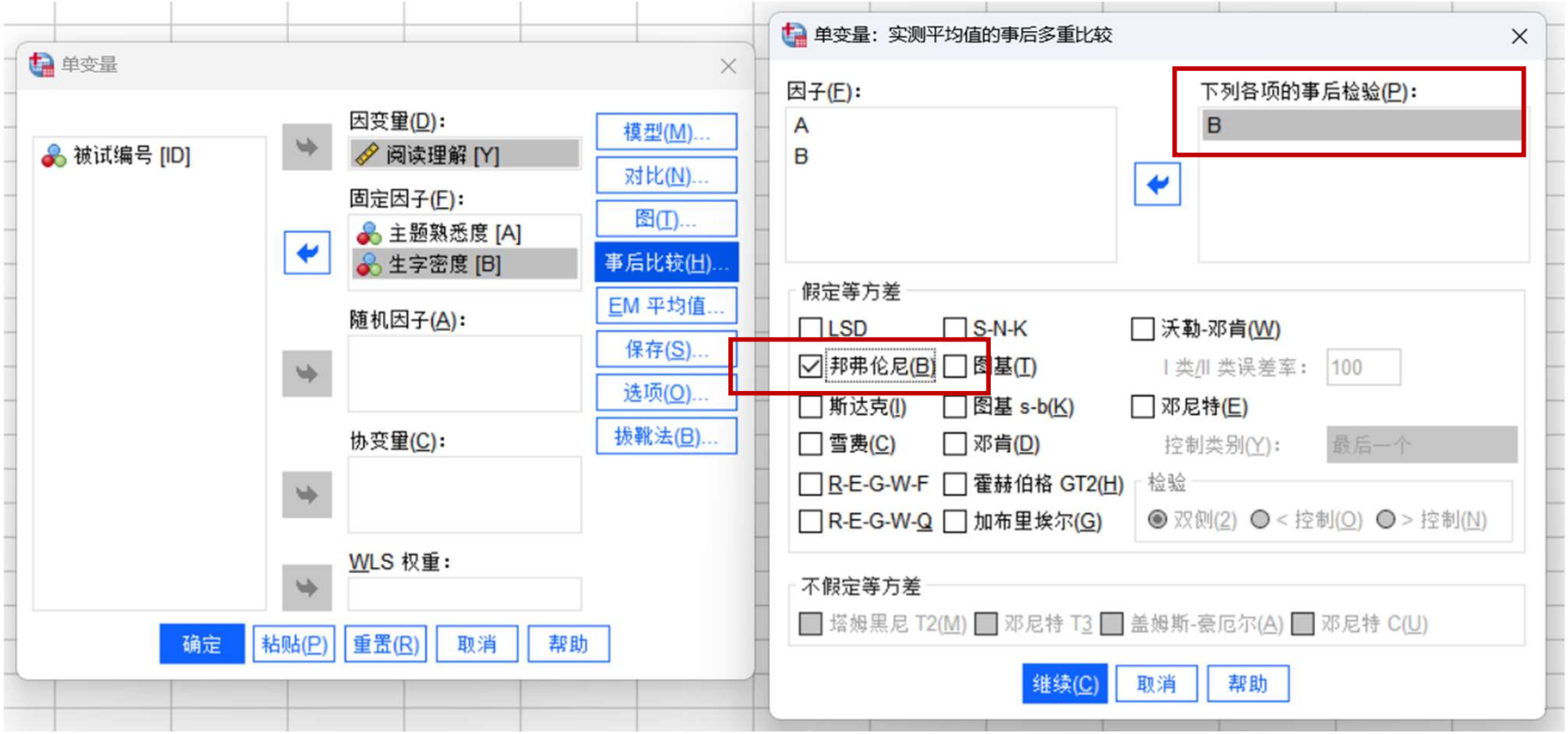
方差分析具有稳健性

1. 两因素完全随机实验设计



1. 两因素完全随机实验设计

1. 两因素完全随机实验设计



只有B（生字密度）具有3个水平，需要事后检验

1. 两因素完全随机实验设计

A 的主效应平均值：因子 A 不同水平下的因变量平均值（排除 B 的影响）。

B 的主效应平均值：因子 B 不同水平下的因变量平均值（排除 A 的影响）。

A*B 的交互作用平均值：因子 A 和 因子 B 每一个组合（交叉点）下的因变量平均值。

1. 两因素完全随机实验设计

1. 两因素完全随机实验设计

可粘贴语句，方便复用


```
DATASET ACTIVATE 数据集1.
UNIANOVA Y BY A B
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /POSTHOC=B(BONFERRONI)
  /EMMEANS=TABLES(A) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(B) COMPARE ADJ(LSD)
  /EMMEANS=TABLES(A*B)
  /PRINT ETASQ DESCRIPTIVE HOMOGENEITY
  /CRITERIA=ALPHA(.05)
  /DESIGN=A B A*B.
```

结果解读-方差齐性

Levene's Test of Equality of Error Variances[a,b]

		Levene Statistic	df1	df2	Sig.
阅读理解	Based on Mean	.605	5	18	.697
	Based on Median	.400	5	18	.842
	Based on Median and with adjusted df	.400	5	11.169	.839
	Based on trimmed mean	.583	5	18	.713

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Dependent variable: 阅读理解

b. Design: Intercept + Familiarity + Density + Familiarity * Density

统计量不显著
满足方差齐性

结果解读-组间检验

最重要的表:被试间效应检验

Tests of Between-Subjects Effects

Dependent Variable: 阅读理解

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	218.333[a]	5	43.667	23.463	<.001	.867
Intercept	888.167	1	888.167	477.224	<.001	.964
A	80.667	1	80.667	43.343	<.001	.707
B	81.083	2	40.542	21.784	<.001	.708
A * B	56.583	2	28.292	15.201	<.001	.628
Error	33.500	18	1.861			
Total	1140.000	24				
Corrected Total	251.833	23				

a. R Squared = .867 (Adjusted R Squared = .830)

两个主效应、交互效应均显著；

需要做**事后检验**和**简单效应检验**

结果解读-多重比较

Post Hoc Tests

生字密度

Multiple Comparisons

Dependent Variable: 阅读理解
Bonferroni

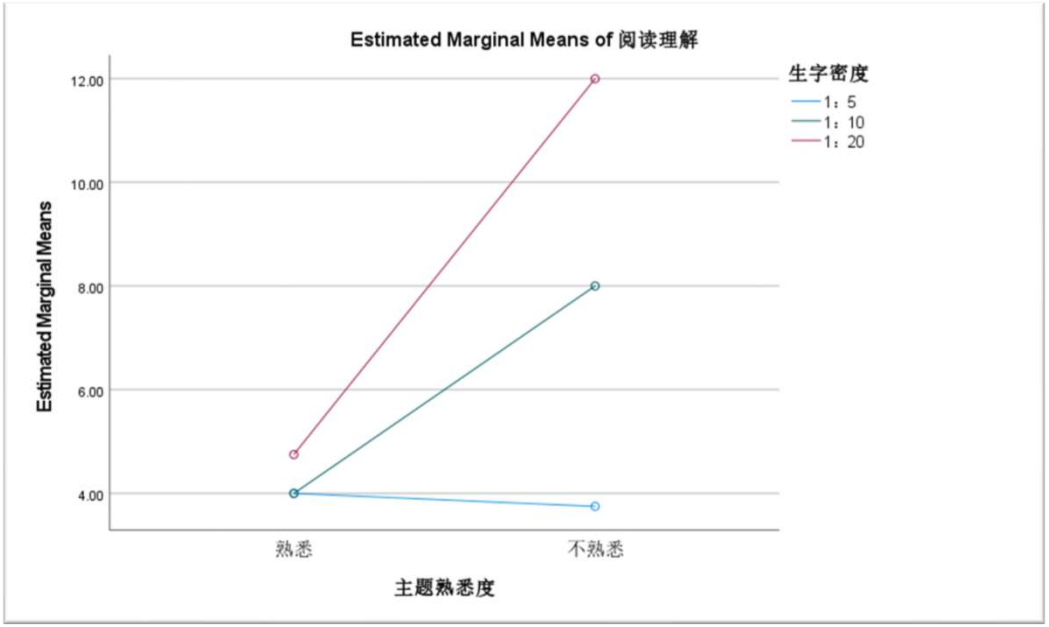
(I) 生字密度	(J) 生字密度	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1：5	1：10	-2.1250*	.68211	.018	-3.9252	-.3248
	1：20	-4.5000*	.68211	<.001	-6.3002	-2.6998
1：10	1：5	2.1250*	.68211	.018	.3248	3.9252
	1：20	-2.3750*	.68211	.008	-4.1752	-.5748
1：20	1：5	4.5000*	.68211	<.001	2.6998	6.3002
	1：10	2.3750*	.68211	.008	.5748	4.1752

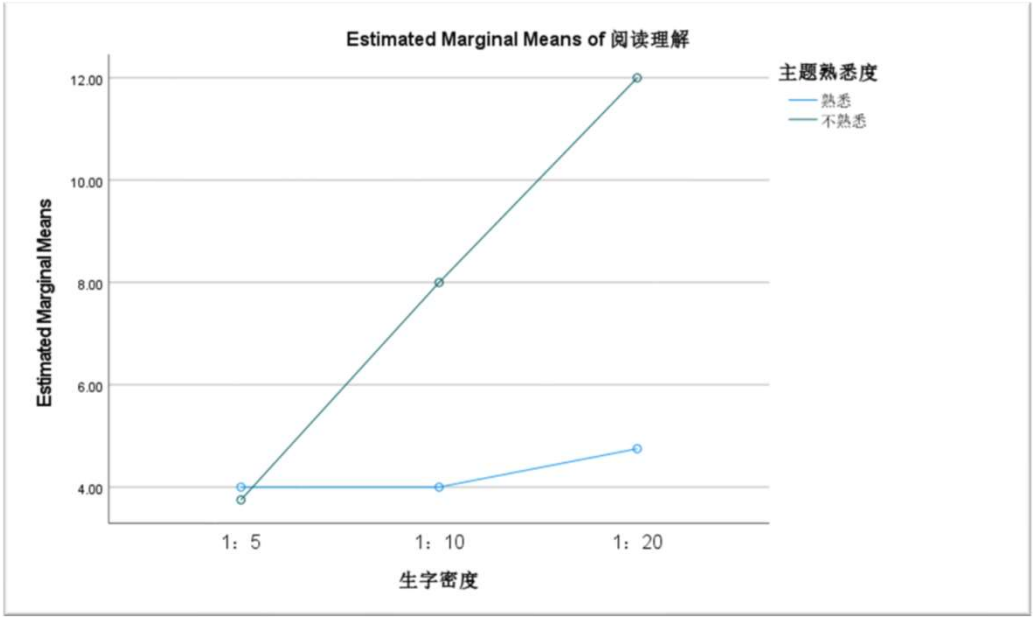
Based on observed means.
The error term is Mean Square(Error) = 1.861.

*. The mean difference is significant at the .05 level.

对于B（生字密度）的事后检验显示：三组之间差异均显著

结果解读-交互作用图


Estimated Marginal Means of 阅读理解
Estimated Marginal Means
12.00
10.00
8.00
6.00
4.00
熟悉
不熟悉
主题熟悉度
生字密度
1：5
1：10
1：20


Estimated Marginal Means of 阅读理解
Estimated Marginal Means
12.00
10.00
8.00
6.00
4.00
1：5
1：10
1：20
生字密度
主题熟悉度
熟悉
不熟悉

结果解读-EM 平均值

1. 主题熟悉度

Estimates

Dependent Variable: 阅读理解

主题熟悉度	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
熟悉	4.250	.394	3.423	5.077
不熟悉	7.917	.394	7.089	8.744

2. 生字密度

Estimates

Dependent Variable: 阅读理解

生字密度	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1：5	3.875	.482	2.862	4.888
1：10	6.000	.482	4.987	7.013
1：20	8.375	.482	7.362	9.388

3. 主题熟悉度 * 生字密度

Dependent Variable: 阅读理解

主题熟悉度	生字密度	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
熟悉	1：5	4.000	.682	2.567	5.433
	1：10	4.000	.682	2.567	5.433
	1：20	4.750	.682	3.317	6.183
不熟悉	1：5	3.750	.682	2.317	5.183
	1：10	8.000	.682	6.567	9.433
	1：20	12.000	.682	10.567	13.433

简单效应检验-语句模板

MANOVA Y BY A(1,2) B(1,3)　　定义变量的水平数

/ERROR=WITHIN　　定义误差项

/DESIGN=B WITHIN A(1), B WITHIN A(2)　　检验B在A1和A2水平上的处理效应

/DESIGN=A WITHIN B(1), A WITHIN B(2), A WITHIN B(3).

检验A在B1、B2、B3水平上的处理效应

* * * * * * * * * * * * * * * * * Analysis of Variance -- Design 1 * * * * * * * * * * * * * * * * *

Tests of Significance for Y using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	33.50	18	1.86		
B WITHIN A(1)	1.50	2	.75	.40	.674
B WITHIN A(2)	136.17	2	68.08	36.58	.000

进一步多重比较

* * * * * * * * * * * * * * * * * Analysis of Variance -- Design 2 * * * * * * * * * * * * * * * * *

Tests of Significance for Y using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	33.50	18	1.86		
A WITHIN B(1)	.13	1	.13	.07	.798
A WITHIN B(2)	32.00	1	32.00	17.19	.001
A WITHIN B(3)	105.13	1	105.13	56.49	.000

二、两因素被试内实验设计

2. 两因素被试内实验设计

研究者希望同时探讨文章**主题熟悉性（A）**和**文章的生字密度（B）**对**学生阅读理解（Y）**的影响。

文章熟悉性：被试内变量，儿童熟悉(a1)；儿童不熟悉（a2）

生字密度：被试内变量，5:1(b1)；10:1(b2)；20:1(b3)

- 2*3 的两因素被试内实验设计
- 6种处理水平的结合，每个被试接受所有处理水平的结合
- 前提：前一篇文章不会对后一篇产生系统性影响
- 4名被试，每个被试阅读6篇文章；为了克服疲劳效应和顺序效应，分6次进行，每次阅读1篇，拉丁方平衡顺序

数据格式

每一个处理水平是一列

	ID	A1B1	A1B2	A1B3	A2B1	A2B2	A2B3
1	1	3.00	4.00	5.00	4.00	8.00	12.00
2	2	6.00	6.00	7.00	5.00	9.00	13.00
3	3	4.00	4.00	5.00	3.00	8.00	12.00
4	4	3.00	2.00	2.00	3.00	7.00	11.00
5							

2. 两因素被试内设计


示题2 [数据集2] - IBM SPSS Statistics 数据编辑器
编辑(E)
查看(V)
数据(D)
转换(T)
分析(A)
图形(G)
实用程序(U)
扩展(X)
窗口(W)
帮助(H)
ID
Familarity
Density1
变量
变量
变量
功效分析(W)
报告(P)
描述统计(E)
贝叶斯统计信息(Y)
表(B)
比较平均值(M)
一般线性模型(G)
广义线性模型(Z)
混合模型(X)
相关(C)
回归(R)
对数线性(O)
单变量(U)...
多变量(M)...
重复测量(R)...
方差成分(V)...


重复测量定义因子
主体内因子名(W):
级别数(L):
添加(A)
更改(C)
除去(M)
A(2)
B(3)
测量名称(N):
添加(D)
更改(H)
除去(V)
定义(F)
重置(R)
取消
帮助

结果解读-球形检验

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Epsilon[b] Huynh-Feldt	Epsilon[b] Lower-bound
A	1.000	.000	0	.	1.000	1.000	1.000
B	.066	5.422	2	.066	.517	.544	.500
A * B	.249	2.780	2	.249	.571	.691	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept
Within Subjects Design: A + B + A * B

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

不显著，满足球形假设

结果解读-方差分析表

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
A	Sphericity Assumed	80.667	1	80.667	72.600	.003	.960
	Greenhouse-Geisser	80.667	1.000	80.667	72.600	.003	.960
	Huynh-Feldt	80.667	1.000	80.667	72.600	.003	.960
	Lower-bound	80.667	1.000	80.667	72.600	.003	.960
Error(A)	Sphericity Assumed	3.333	3	1.111			
	Greenhouse-Geisser	3.333	3.000	1.111			
	Huynh-Feldt	3.333	3.000	1.111			
	Lower-bound	3.333	3.000	1.111			
B	Sphericity Assumed	81.083	2	40.542	153.632	<.001	.981
	Greenhouse-Geisser	81.083	1.034	78.388	153.632	<.001	.981
	Huynh-Feldt	81.083	1.087	74.562	153.632	<.001	.981
	Lower-bound	81.083	1.000	81.083	153.632	.001	.981
Error(B)	Sphericity Assumed	1.583	6	.264			
	Greenhouse-Geisser	1.583	3.103	.510			
	Huynh-Feldt	1.583	3.262	.485			
	Lower-bound	1.583	3.000	.528			
A * B	Sphericity Assumed	56.583	2	28.292	119.824	<.001	.976
	Greenhouse-Geisser	56.583	1.142	49.535	119.824	<.001	.976
	Huynh-Feldt	56.583	1.383	40.914	119.824	<.001	.976
	Lower-bound	56.583	1.000	56.583	119.824	.002	.976
Error(A*B)	Sphericity Assumed	1.417	6	.236			
	Greenhouse-Geisser	1.417	3.427	.413			
	Huynh-Feldt	1.417	4.149	.341			
	Lower-bound	1.417	3.000	.472			

B的多重比较

Pairwise Comparisons

Measure: MEASURE_1

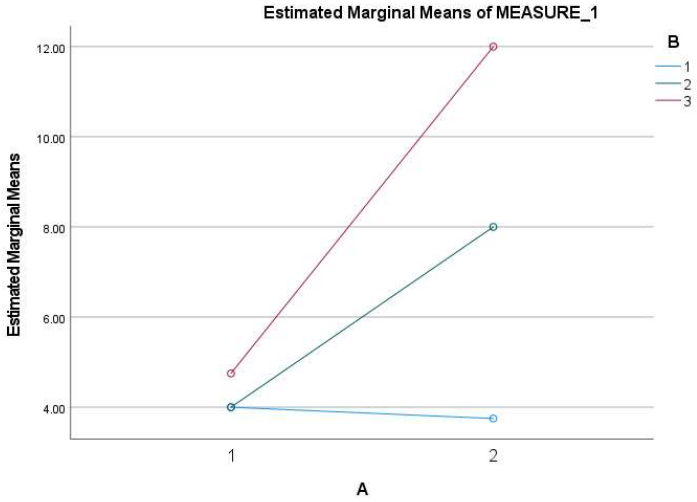
(I) B	(J) B	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-2.125*	.239	.009	-3.287	-.963
	3	-4.500*	.354	.003	-6.217	-2.783
2	1	2.125*	.239	.009	.963	3.287
	3	-2.375*	.125	<.001	-2.982	-1.768
3	1	4.500*	.354	.003	2.783	6.217
	2	2.375*	.125	<.001	1.768	2.982

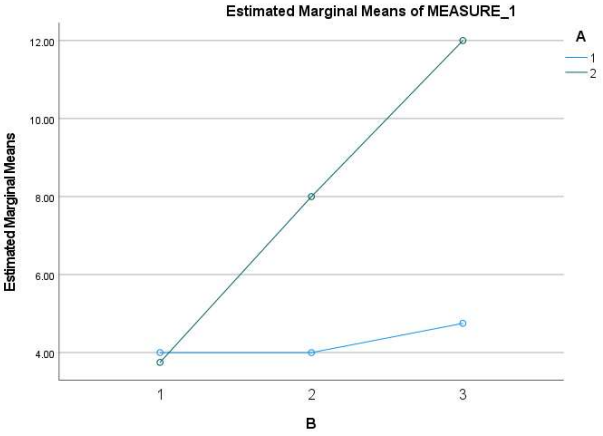
Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

结果解读-交互作用图与均值表





1. A

Measure: MEASURE_1

A	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	4.250	.821	1.638	6.862
2	7.917	.417	6.591	9.243

2. B

Measure: MEASURE_1

B	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	3.875	.554	2.111	5.639
2	6.000	.612	4.051	7.949
3	8.375	.718	6.090	10.660

3. A * B

Measure: MEASURE_1

A	B	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1	1	4.000	.707	1.750	6.250
	2	4.000	.816	1.402	6.598
	3	4.750	1.031	1.470	8.030
2	1	3.750	.479	2.227	5.273
	2	8.000	.408	6.701	9.299
	3	12.000	.408	10.701	13.299

2. 简单效应检验

检验B因素在A1、A2水平上的处理效应

```
MANOVA A1B1 A1B2 A1B3 A2B1 A2B2 A2B3
    /WSFACTORS=A(2) B(3)
    /WSDESIGN= B WITHIN A(1)
               B WITHIN A(2).
```

指定被试内因素

定义简单效应项

******************Analysis of Variance -- Design 1******************

Tests involving 'B WITHIN A(1)' Within-Subject Effect.

AVERAGED Tests of Significance for MEAS.1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.50	6	.42		
B WITHIN A(1)	1.50	2	.75	1.80	.244

******************Analysis of Variance -- Design 1******************

EFFECT .. B WITHIN A(2)

Tests involving 'B WITHIN A(2)' Within-Subject Effect.

AVERAGED Tests of Significance for MEAS.1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	.50	6	.08		
B WITHIN A(2)	136.17	2	68.08	817.00	.000

- -

2. 两因素被试内设计

检验A因素在B1、B2、B3水平上的处理效应

```
MANOVA A1B1 to A2B3
/WSFACTORS=A(2) B(3)
/WSDESIGN=
        A WITHIN B(1)
        A WITHIN B(2)
        A WITHIN B(3).
```

小技巧：使用to，只用写出开头和结尾的变量

Tests involving 'A WITHIN B(1)' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	1.38	3	.46		
A WITHIN B(1)	.13	1	.13	.27	.638

- -

* * * * * * * * * * * * * * * * * * A n a l y s i s   o f   V a r i a n c e -- Design 1 * * * * * * * * * * * * * * * * * *

Tests involving 'A WITHIN B(2)' Within-Subject Effect.

Tests of Significance for T3 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	1.00	3	.33		
A WITHIN B(2)	32.00	1	32.00	96.00	.002

- -

***************** A n a l y s i s   o f   V a r i a n c e -- Design 1 *****************

Tests involving 'A WITHIN B(3)' Within-Subject Effect.

Tests of Significance for T4 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.38	3	.79		
A WITHIN B(3)	105.13	1	105.13	132.79	.001

\- -

三、两因素混合实验设计

3.两因素混合实验设计

研究者希望同时探讨文章**主题熟悉性（A）**和**文章的生字密度（B）**对**学生阅读理解（Y）**的影响。

文章熟悉性：被试间变量，儿童熟悉(a1)；儿童不熟悉（a2）

生字密度：被试内变量，5:1(b1)；10:1(b2)；20:1(b3)

- 2*3 的两因素混合实验设计
- 6种处理水平的结合，每个被试接受3种处理水平的结合
- 8名五年级学生随机分为2组，一组的学生阅读3篇生字密度不同的、**主题熟悉**的文章；另一组阅读3篇生字密度不同的、主题**不熟悉**的文章
- 实验实施时，阅读三篇文章**分3次进行**，采用**拉丁方设计**平衡文章先后顺序

数据结构

	因素A	B1	B2	B3
被试1	A取值	分数1	分数2	分数3
被试2	-	-	-	
被试3	-	-	-	

被试间变量用一列标识，被试内变量展开

ID	A	B1	B2	B3
1	1	3.00	4.00	5.00
2	1	6.00	6.00	7.00
3	1	4.00	4.00	5.00
4	1	3.00	2.00	2.00
5	2	4.00	8.00	12.00
6	2	5.00	9.00	13.00
7	2	3.00	8.00	12.00
8	2	3.00	7.00	11.00

3.两因素混合实验设计


示题2 [数据集2] - IBM SPSS Statistics 数据编辑器
编辑(E)
查看(V)
数据(D)
转换(T)
分析(A)
图形(G)
实用程序(U)
扩展(X)
窗口(W)
帮助(H)
功效分析(W)
报告(P)
描述统计(E)
贝叶斯统计信息(Y)
表(B)
比较平均值(M)
一般线性模型(G)
广义线性模型(Z)
混合模型(X)
相关(C)
回归(R)
对数线性(O)
单变量(U)...
多变量(M)...
重复测量(R)...
方差成分(V)...
ID
Familarity
Density1
变量
变量
变量

3.两因素混合实验设计

定义被试内变量

定义被试间变量

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b] Greenhouse-Geisser	Epsilon[b] Huynh-Feldt	Epsilon[b] Lower-bound
B	.157	9.245	2	.010	.543	.680	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + A
Within Subjects Design: B

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

违背球形检验，使用Greenhouse-Geisser矫正

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
B	Sphericity Assumed	81.083	2	40.542	162.167	<.001	.964
	Greenhouse-Geisser	81.083	1.085	74.702	162.167	<.001	.964
	Huynh-Feldt	81.083	1.360	59.624	162.167	<.001	.964
	Lower-bound	81.083	1.000	81.083	162.167	<.001	.964
B * A	Sphericity Assumed	56.583	2	28.292	113.167	<.001	.950
	Greenhouse-Geisser	56.583	1.085	52.130	113.167	<.001	.950
	Huynh-Feldt	56.583	1.360	41.608	113.167	<.001	.950
	Lower-bound	56.583	1.000	56.583	113.167	<.001	.950
Error(B)	Sphericity Assumed	3.000	12	.250			
	Greenhouse-Geisser	3.000	6.513	.461			
	Huynh-Feldt	3.000	8.160	.368			
	Lower-bound	3.000	6.000	.500			

被试内变量主效应+ 交互效应

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	888.167	1	888.167	174.721	<.001	.967
A	80.667	1	80.667	15.869	.007	.726
Error	30.500	6	5.083			

被试间变量主效应显著

Pairwise Comparisons

Measure: MEASURE_1

(I) B	(J) B	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
1	2	-2.125*	.239	<.001	-2.912	-1.338
	3	-4.500*	.339	<.001	-5.613	-3.387
2	1	2.125*	.239	<.001	1.338	2.912
	3	-2.375*	.125	<.001	-2.786	-1.964
3	1	4.500*	.339	<.001	3.387	5.613
	2	2.375*	.125	<.001	1.964	2.786

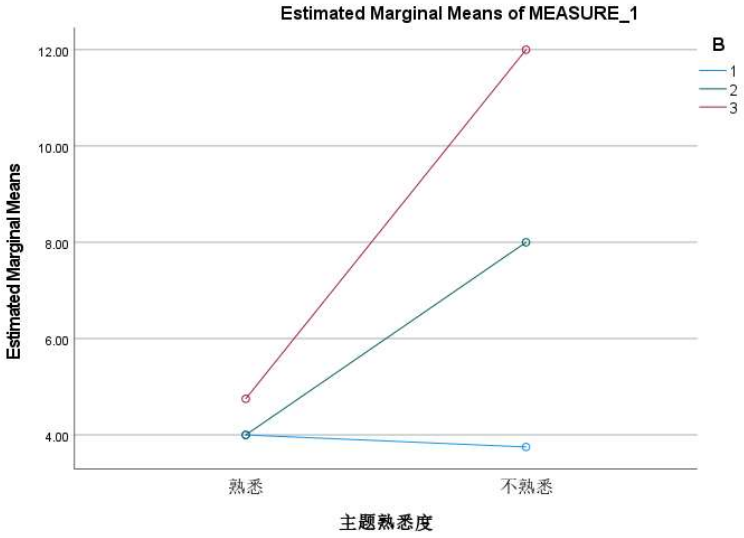
Based on estimated marginal means

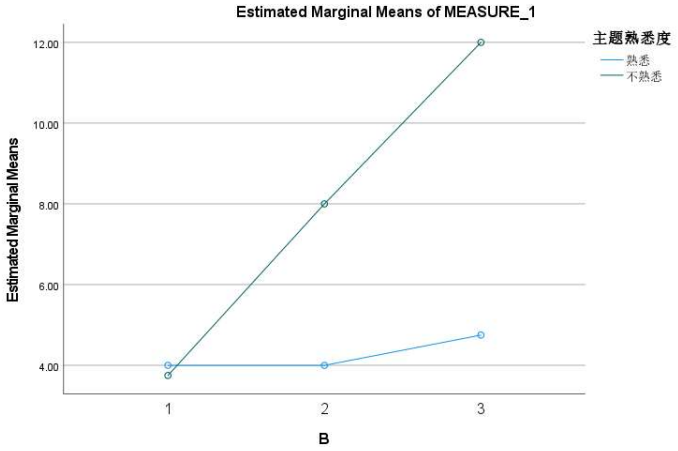
*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

B因素的多重比较

结果解读-交互作用图与均值表





1. 主题熟悉度

Measure: MEASURE_1

主题熟悉度	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
熟悉	4.250	.651	2.657	5.843
不熟悉	7.917	.651	6.324	9.509

2. B

Measure: MEASURE_1

B	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	3.875	.427	2.830	4.920
2	6.000	.456	4.883	7.117
3	8.375	.554	7.019	9.731

3. 主题熟悉度 * B

Measure: MEASURE_1

主题熟悉度	B	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
熟悉	1	4.000	.604	2.523	5.477
	2	4.000	.645	2.421	5.579
	3	4.750	.784	2.832	6.668
不熟悉	1	3.750	.604	2.273	5.227
	2	8.000	.645	6.421	9.579
	3	12.000	.784	10.082	13.918

简单效应检验

B因素在A1、A2水平上的处理效应（被试内因素在被试间因素上的简单效应）

```
MANOVA B1 B2 B3 BY A(1,2)        声明变量
  /WSFACTOR=B(3)                 指定被试内因素
  /ERROR=WITHIN                  定义误差项
  /WSDESIGN=B                    声明被试内设计
  /DESIGN=MWITHIN A(1),
          MWITHIN A(2).          被试内变量的简单效应
```

简单效应检验

******************A n a l y s i s   o f   V a r i a n c e -- Design   1*****************

Tests involving 'B' Within-Subject Effect.

AVERAGED Tests of Significance for B using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	3.00	12	.25		
MWITHIN A(1) BY B	1.50	2	.75	3.00	.088
MWITHIN A(2) BY B	136.17	2	68.08	272.33	.000

- -

简单效应检验

A因素在B1、B2、B3水平上的差异（被试间因素在被试内因素上的简单效应）

```
MANOVA B1 B2 B3 BY A(1,2)
WSFACTOR=B(3)
/ERROR=WITHIN
/WSDESIGN= MWITHIN B(1), MWITHIN B(2),
           MWITHIN B(3)
/DESIGN=A.
```

指定B因素的不同水平，“切面”操作

简单效应检验

北京師範大學 BEIJING NORMAL UNIVERSITY

*****************Analysis of Variance -- Design 1*****************

Tests involving 'MWITHIN B(1)' Within-Subject Effect.

Tests of Significance for T1 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	8.75	6	1.46		
MWITHIN B(1)	120.13	1	120.13	82.37	.000
A BY MWITHIN B(1)	.13	1	.13	.09	.780

*****************Analysis of Variance -- Design 1*****************

Tests involving 'MWITHIN B(2)' Within-Subject Effect.

Tests of Significance for T2 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	10.00	6	1.67		
MWITHIN B(2)	288.00	1	288.00	172.80	.000
A BY MWITHIN B(2)	32.00	1	32.00	19.20	.005

*****************Analysis of Variance -- Design 1*****************

Tests involving 'MWITHIN B(3)' Within-Subject Effect.

Tests of Significance for T3 using UNIQUE sums of squares

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN CELLS	14.75	6	2.46		
MWITHIN B(3)	561.13	1	561.13	228.25	.000
A BY MWITHIN B(3)	105.13	1	105.13	42.76	.001

四、拓展 R-BruceR

使用R-BruceR 进行方差分析，以两因素混合方差分析为例

宽数据

ID	A	B1	B2	B3
1	1	3.00	4.00	5.00
2	1	6.00	6.00	7.00
3	1	4.00	4.00	5.00
4	1	3.00	2.00	2.00
5	2	4.00	8.00	12.00
6	2	5.00	9.00	13.00
7	2	3.00	8.00	12.00
8	2	3.00	7.00	11.00

pivot_longer

长数据

	ID	A	Condition_B	Score
1	1	1	B1	3
2	1	1	B2	4
3	1	1	B3	5
4	2	1	B1	6
5	2	1	B2	6
6	2	1	B3	7
7	3	1	B1	4
8	3	1	B2	4
9	3	1	B3	5

使用R-BruceR 进行方差分析

```
31
32  # 2. 运行方差分析
33  library(bruceR)
34
35  model <- MANOVA(
36    data = df_long,
37    subID = "ID",                 # 被试编号
38    dv = "Score",                 # 因变量 (分数)
39    between = "A",                # 被试间因子
40    within = "B",                 # 被试内因子
41    sph.correction = "GG" # 球形度校正 (Greenhouse-Geisser)
42  )
43
```

```
====== ANOVA (Mixed Design) ======

Descriptives:
-----------------------------
 "A" "B"    Mean     S.D. n
-----------------------------
  A1  B1  4.000 (1.414) 4
  A1  B2  4.000 (1.633) 4
  A1  B3  4.750 (2.062) 4
  A2  B1  3.750 (0.957) 4
  A2  B2  8.000 (0.816) 4
  A2  B3 12.000 (0.816) 4
-----------------------------
Total sample size: N = 8
```

```
ANOVA Table:
Dependent variable(s):      Score
Between-subjects factor(s): A
Within-subjects factor(s):  B
Covariate(s):               -
-------------------------------------------------------------------------------------------
          MS   MSE   df1   df2       F     p     η²p [90% CI of η²p]  η²G
-------------------------------------------------------------------------------------------
A     80.667 5.083 1.000 6.000  15.869  .007 **    .726 [.248, .871] .707
B     74.702 0.461 1.085 6.513 162.167 <.001 ***   .964 [.880, .983] .708
A * B 52.130 0.461 1.085 6.513 113.167 <.001 ***   .950 [.833, .976] .628
-------------------------------------------------------------------------------------------
```

多重比较和简单效应检验 —— EMMEANS

```
41
42  cat("\n\n=== 3. 主效应多重比较  ===\n")
43
44  # 检验变量 B 的主效应 (B1 vs B2 vs B3)
45  EMMEANS(model, effect = "B", p.adjust = "bonferroni")
46
47
48  cat("\n\n=== 4.1 简单效应：固定 A，看 B 的差异 (最常用) ===\n")
49  # 含义：在 A1 水平下，B1/B2/B3 有差异吗？在 A2 水平下呢？
50  sim_eff_B_by_A <- EMMEANS(model, effect = "B", by = "A", p.adjust = "bonferroni")
51  print(sim_eff_B_by_A)
52
53  cat("\n\n=== 4.2 简单效应：固定 B，看 A 的差异 ===\n")
54  # 含义：在 B1 阶段，A1 和 A2 有差异吗？在 B3 阶段呢？
55  sim_eff_A_by_B <- EMMEANS(model, effect = "A", by = "B", p.adjust = "bonferroni")
56  print(sim_eff_A_by_B)
57
```

B的多重比较

Estimated Marginal Means of "B":

"B"	Mean	[95% CI of Mean]	S.E.
B1	3.875	[2.830, 4.920]	(0.427)
B2	6.000	[4.883, 7.117]	(0.456)
B3	8.375	[7.019, 9.731]	(0.554)

Pairwise Comparisons of "B":

Contrast	Estimate	S.E.	df	t	p	Cohen's d	[95% CI of d]
B2 - B1	2.125	(0.239)	6	8.878	<.001 ***	3.246	[2.044, 4.448]
B3 - B1	4.500	(0.339)	6	13.294	<.001 ***	6.874	[5.174, 8.574]
B3 - B2	2.375	(0.125)	6	19.000	<.001 ***	3.628	[3.000, 4.256]

Joint Tests of "A":

Effect	"B"	df1	df2	F	p	η²p [90% CI of η²p]
A	B1	1	6	0.086	.780	.014 [.000, .339]
A	B2	1	6	19.200	.005 **	.762 [.314, .888]
A	B3	1	6	42.763	<.001 ***	.877 [.593, .942]

Note. Simple effects of *repeated measures* with 3 or more levels are *different* from the results obtained with SPSS MANOVA syntax.

A的简单效应

Joint Tests of "B":

Effect	"A"	df1	df2	F	p	η²p [90% CI of η²p]
B	A1	2	6	17.471	.003 **	.853 [.492, .930]
B	A2	2	6	265.941	<.001 ***	.989 [.959, .995]

Note. Simple effects of *repeated measures* with 3 or more levels are *different* from the results obtained with SPSS MANOVA syntax.

B的简单效应

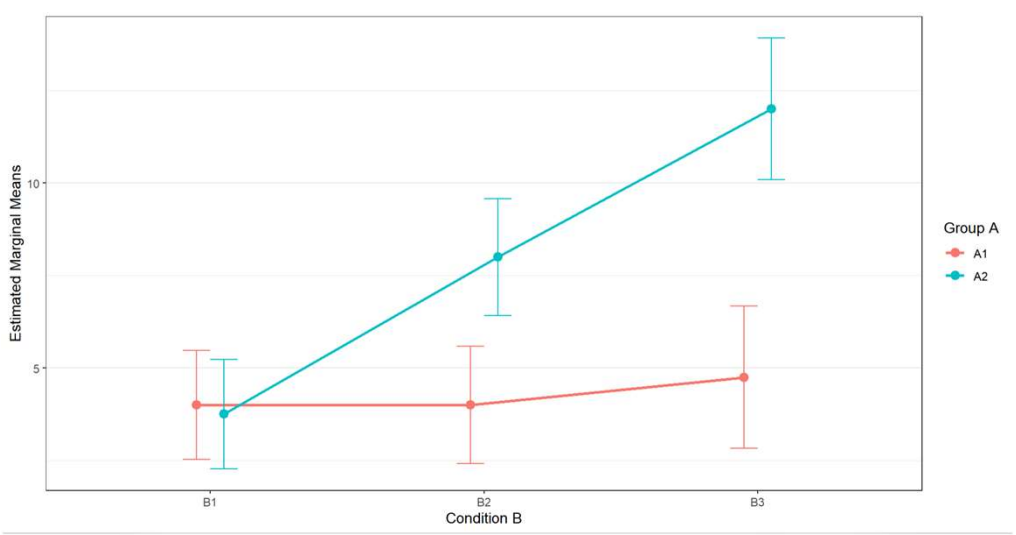
Pairwise Comparisons of "B":

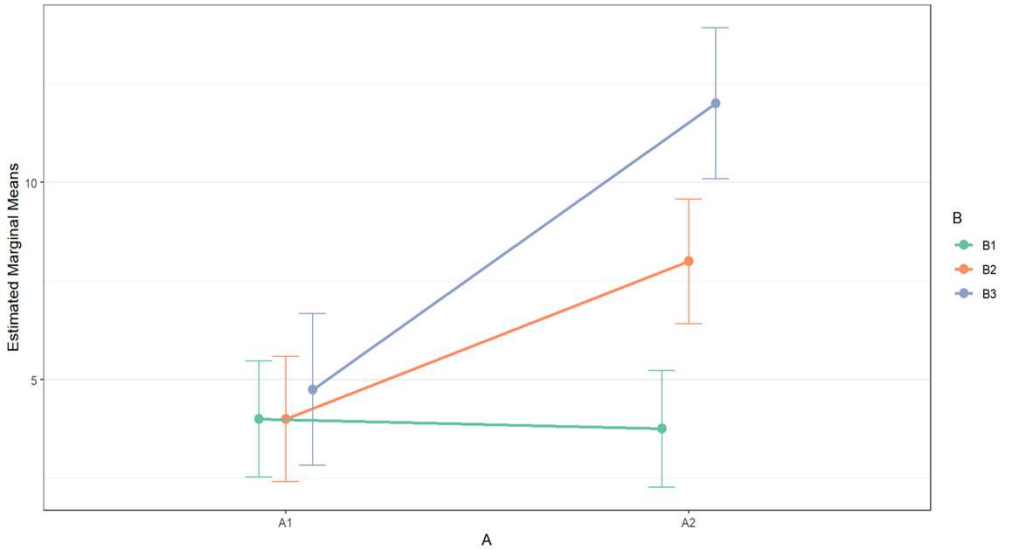
Contrast	"A"	Estimate	S.E.	df	t	p	Cohen's d [95% CI of d]
B2 - B1	A1	0.000	(0.339)	6	0.000	1.000	0.000 [-1.700, 1.700]
B3 - B1	A1	0.750	(0.479)	6	1.567	.505	1.146 [-1.258, 3.550]
B3 - B2	A1	0.750	(0.177)	6	4.243	.016 *	1.146 [0.258, 2.033]
B2 - B1	A2	4.250	(0.339)	6	12.555	<.001 ***	6.492 [4.792, 8.192]
B3 - B1	A2	8.250	(0.479)	6	17.234	<.001 ***	12.602 [10.198, 15.006]
B3 - B2	A2	4.000	(0.177)	6	22.627	<.001 ***	6.110 [5.222, 6.998]

Pooled SD for computing Cohen's d: 0.655
P-value adjustment: Bonferroni method for 3 tests.

B简单效应的多重比较

配合ggplot，更加灵活的绘图





本次教程中，所有的原始数据、代码、ppt均上传至：

https://github.com/CANDYCHEN111/tutorial-on-two-way-ANOVA