

Chp69-1. Evaluating Customer Dwell Time for Three E-commerce Ads A/B/C: Handling Unequal Variances When Samples Follow a Normal Distribution (Using SPSS Software Analysis, Shapiro-Wilk Normality Test + Welch ANOVA Test + Games-Howell Post-hoc Test)

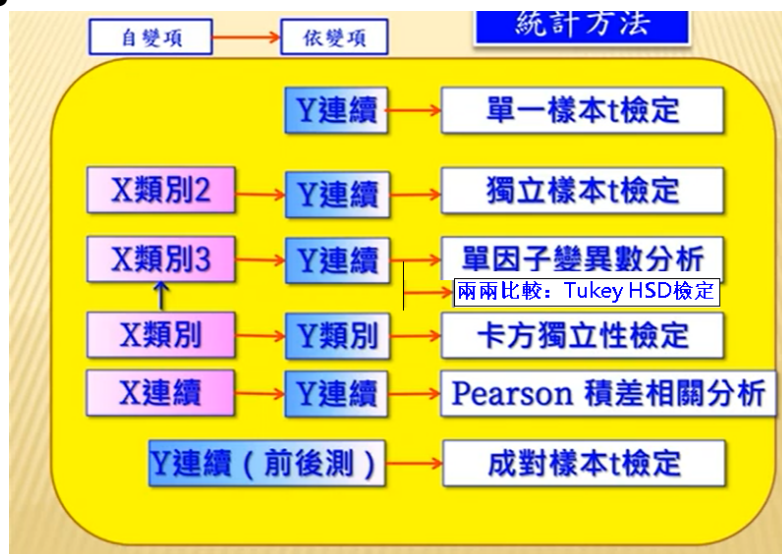
(1). [Concept]: Complexities and Difficulties of One-Way ANOVA: It has 3 basic assumption limitations

3 Basic Assumptions of One-Way ANOVA:

1. Samples in each group are independent
2. Each sample comes from a normally distributed population
3. The variances of each population are equal

(2). [Statistical Test Judgment Diagram]: Basic Diagram, Advanced Diagram

2-1 Basic Diagram



2-2 Advanced Diagram (ANOVA Test)

✓ 單因子變異數分析 (One-Way ANOVA) 檢定流程與事後檢定對照表

狀況	建議方法	事後檢定方式 (Post Hoc Test)
母體 ≥ 3 , 常態分布、變異數相等	One-Way ANOVA	Tukey HSD (最常用) 、Bonferroni 、Scheffé
母體 ≥ 3 , 常態分布、變異數不等	Welch ANOVA	Games-Howell (適用變異數不齊)
母體 ≥ 3 , 非常態分布	Kruskal-Wallis Test	Dunn's Test (需 Bonferroni 或 Holm 校正)

(3). [SPSS Implementation]: Therefore, the first step in performing one-way ANOVA is to check: whether the samples conform to a normal distribution?

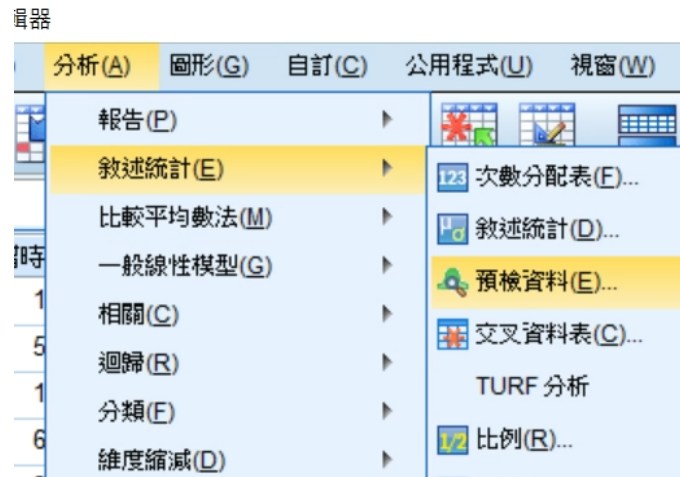
How to Perform the Shapiro-Wilk Normality Test in SPSS

1. Open SPSS and Load Data

The screenshot shows the SPSS data view with three variables: ID (数值, 宽度 3, 小数 0), 廣告 (数值, 宽度 1, 小数 0), and 停留時間 (数值, 宽度 6, 小数 2). The '廣告' variable is highlighted in yellow. Overlaid on the data view is the '值標籤' (Value Labels) dialog box. The dialog box has a title bar '值標籤' and a subtitle '值標籤'. It contains two input fields: '值(U):' and '標籤(L):'. Below these fields is a list box containing three items: '1 = "廣告 1"', '2 = "廣告 2"', and '3 = "廣告 3"'. To the left of the list box are three buttons: '新增(A)', '變更(C)', and '移除(M)'. At the bottom of the dialog box are three buttons: '確定', '取消', and '說明'.

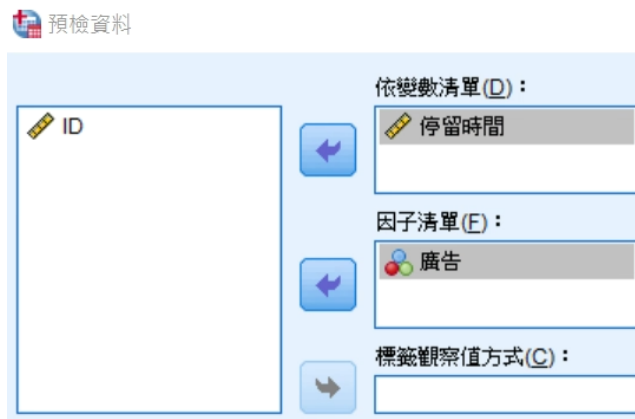
2. Select Statistical Test Path

- Click Analyze → Descriptive Statistics → Explore.



3. Set Variables

- In the Dependent List, select the numerical variable to be tested for normality.
- In the Factor List, you can select a categorical variable (optional).



4. Enable Normality Test

- Click the Plots button.
- On the Descriptive page, check Normality plots with tests.
- **Ensure the Shapiro-Wilk test is included (**
- **SPSS automatically calculates Shapiro-Wilk when the sample size is less than 50.**
- **Kolmogorov-Smirnov test is provided when the sample size exceeds 50).**



How to Interpret the Results

- In the output's Tests of Normality table:
 - Shapiro-Wilk's p-value (Sig.)**
 - If $p > 0.05$, it indicates that the data conforms to a normal distribution.
 - If $p \leq 0.05$, it indicates that the data significantly deviates from a normal distribution.

常態檢定

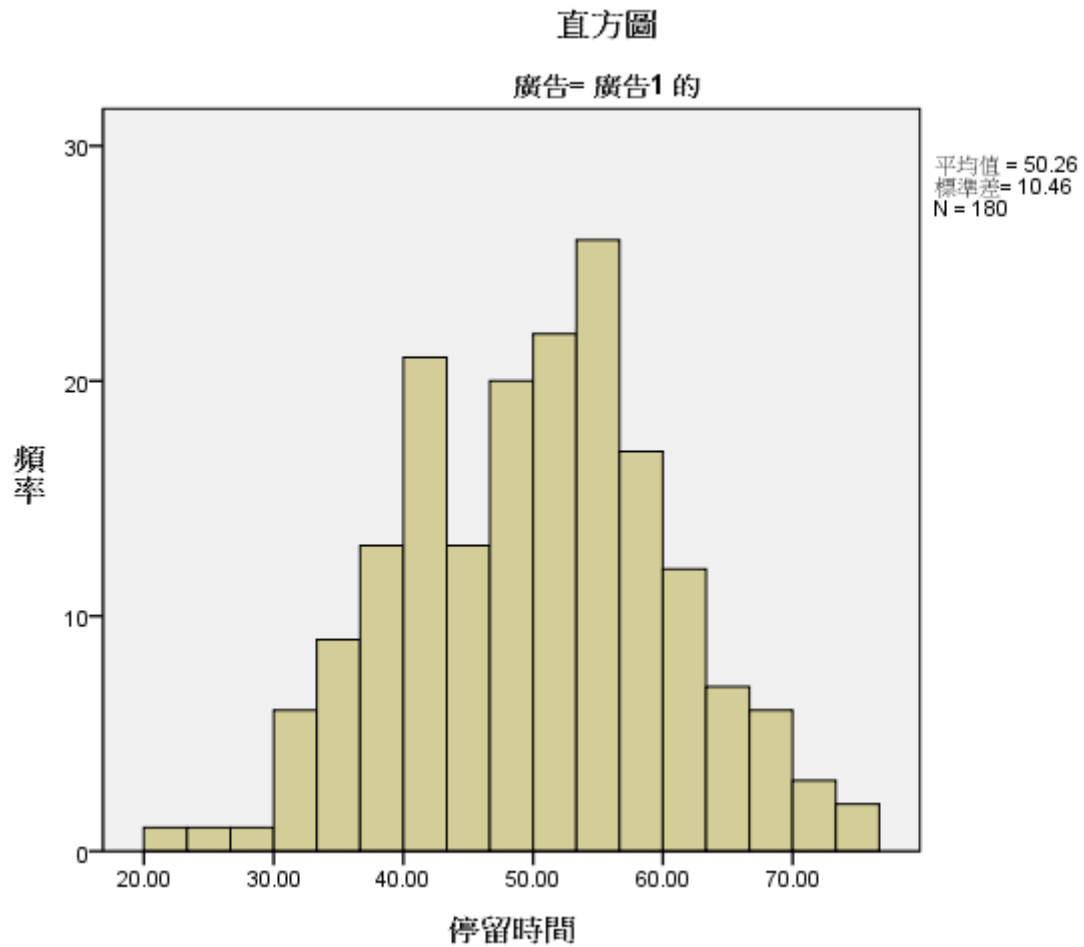
		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
廣告		統計量	自由度	顯著性	統計量	自由度	顯著性
停留時間	廣告1	.049	180	.200 [*]	.995	180	.805
	廣告2	.043	180	.200 [*]	.995	180	.827
	廣告3	.034	180	.200 [*]	.996	180	.932

Conclusion: Because the sample size is 450, refer to the

[Kolmogorov-Smirnov Test]

Significance p-value $0.2 > 0.05$, so it indicates that the data conforms to a normal distribution

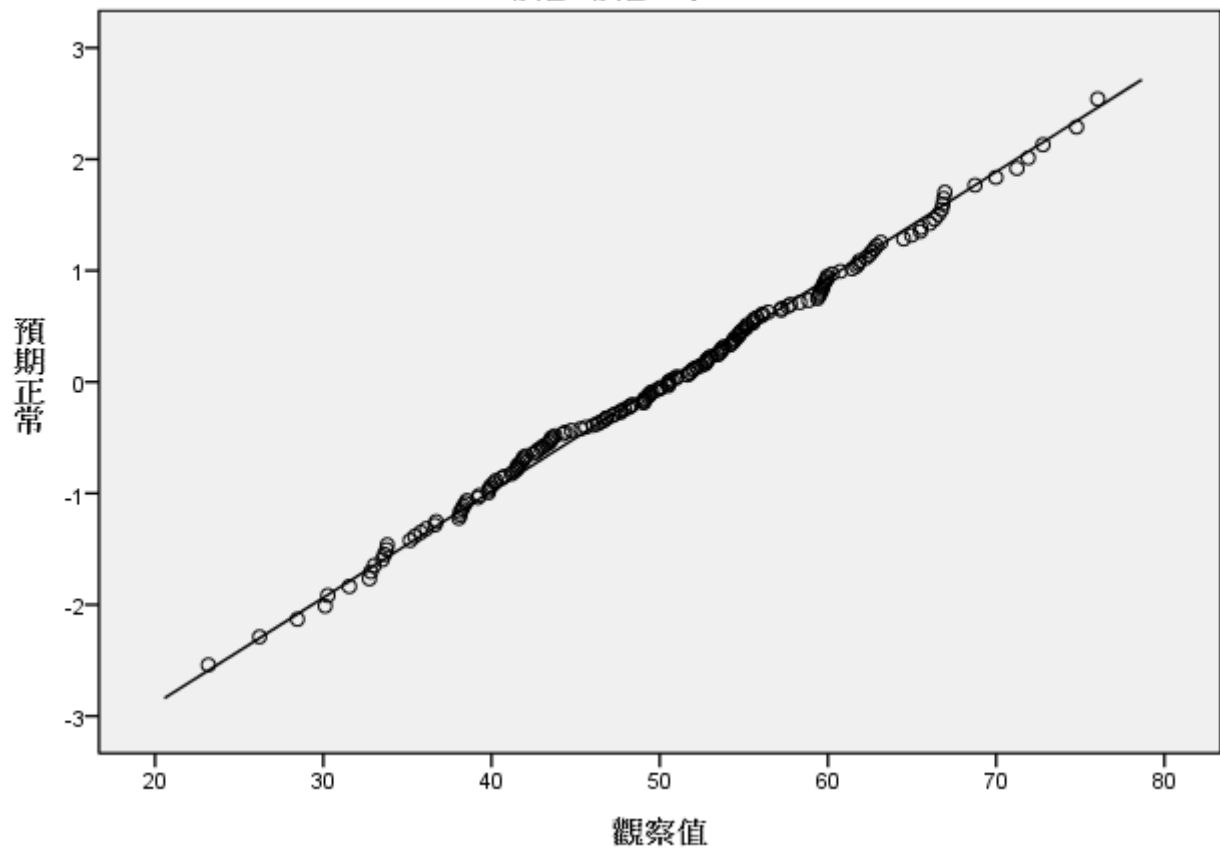
Graphical Proof 1: Histogram



Graphical Proof 2: QQ Plot (Data must be on a straight line to be normally distributed)

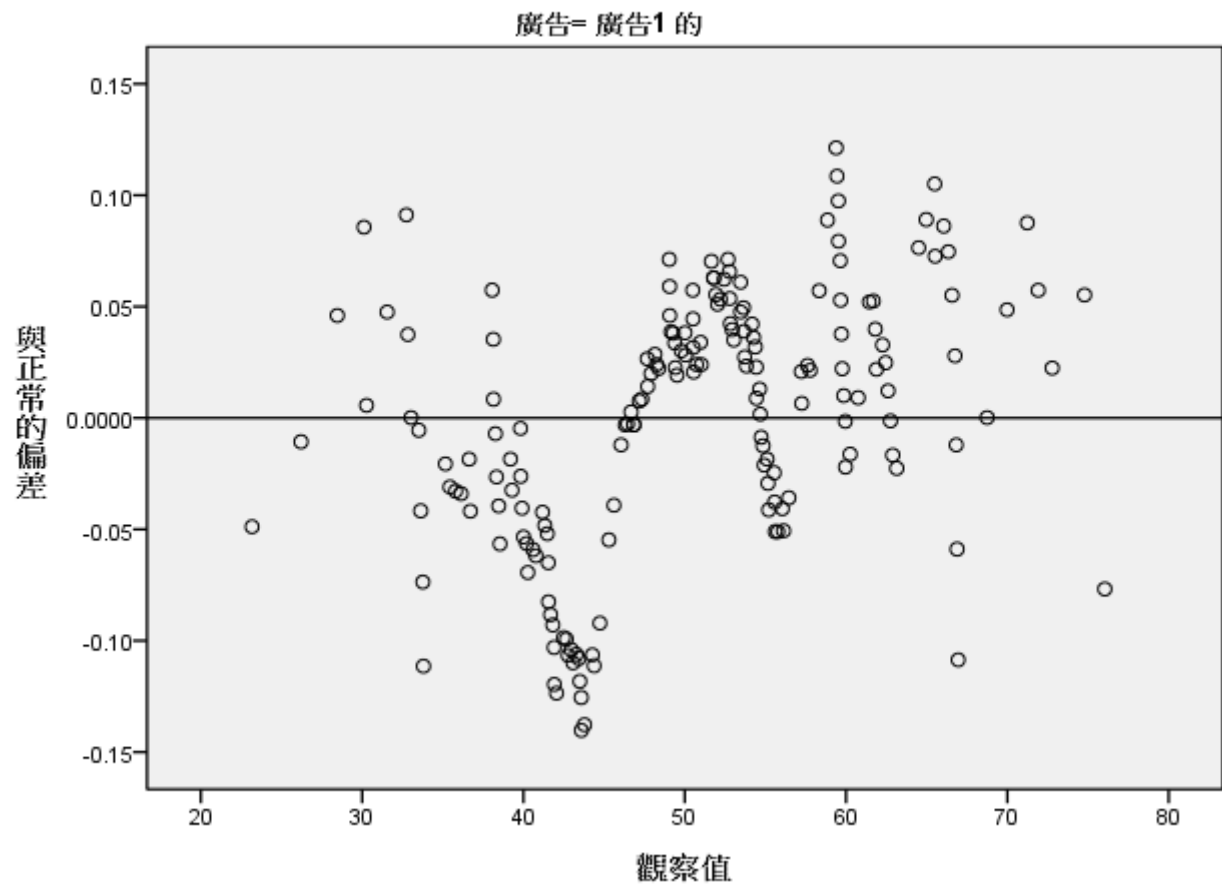
停留時間的常態 Q-Q 圖

廣告= 廣告1 的

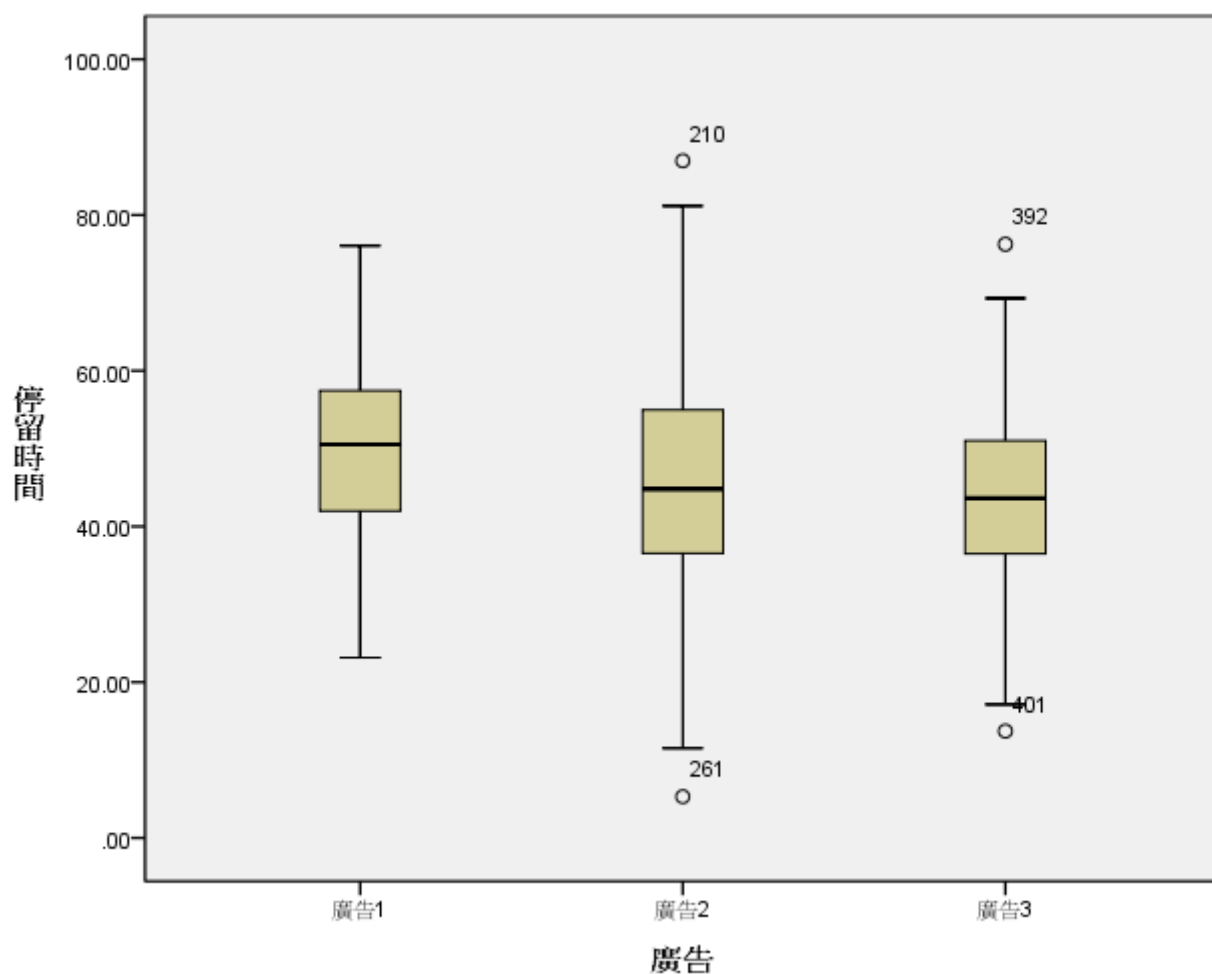


Graphical Proof 3: Detrended Normal QQ Plot (Data must be close to the horizontal 0 axis to be normally distributed)

停留時間的除勢常態 Q-Q 圖



Graphical Proof 4: Box Plot (Data must have no outliers outside the quartiles to be normally distributed)



(4). [Concept]: If the data does not conform to a normal distribution, and the variances are not equal, ANOVA test cannot be used; Welch ANOVA test must be used instead

3 Basic Assumptions of One-Way ANOVA:

1. Samples in each group are independent
2. Each sample comes from a normally distributed population
3. The variances of each population are equal

Advanced Diagram (ANOVA Test)

✅ 單因子變異數分析 (One-Way ANOVA) 檢定流程與事後檢定對照表

狀況	建議方法	事後檢定方式 (Post Hoc Test)
母體 ≥ 3 , 常態分布、變異數相等	One-Way ANOVA	Tukey HSD (最常用) 、Bonferroni 、Scheffé
母體 ≥ 3 , 常態分布、變異數不等	Welch ANOVA	Games-Howell (適用變異數不齊)
母體 ≥ 3 , 非常態分布	Kruskal-Wallis Test	Dunn's Test (需 Bonferroni 或 Holm 校正)

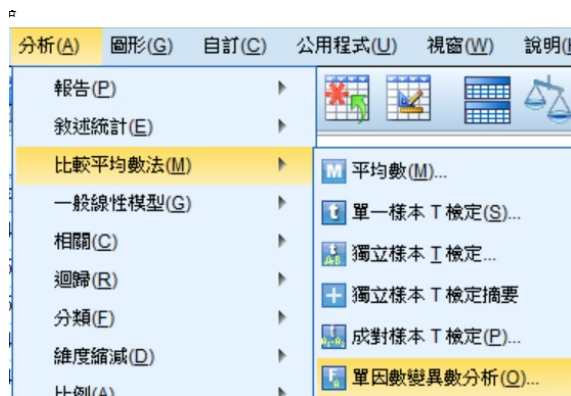
(5). [SPSS Implementation]: Welch ANOVA Test

In SPSS, when dealing with 3 groups of population samples and wanting to perform one-way ANOVA, it is necessary to check whether the variances are equal (homogeneity of variance) before formal analysis. This check is usually performed through Levene's Test.

✓ SPSS Steps to Check if Variances are Equal (Levene's Test)

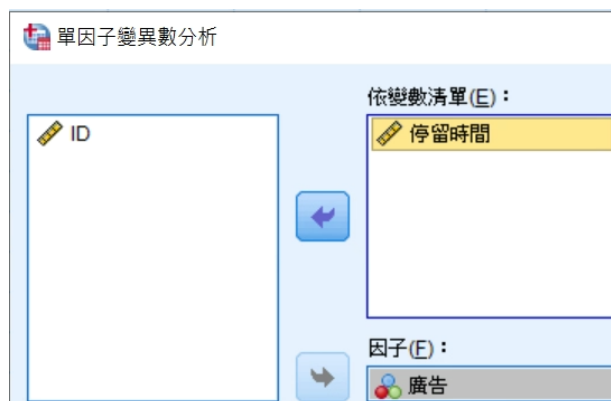
📌 SPSS Operation Steps:

1. Open the Data File
2. Click Menu: **Analyze** → **Compare Means** → **One-Way ANOVA**



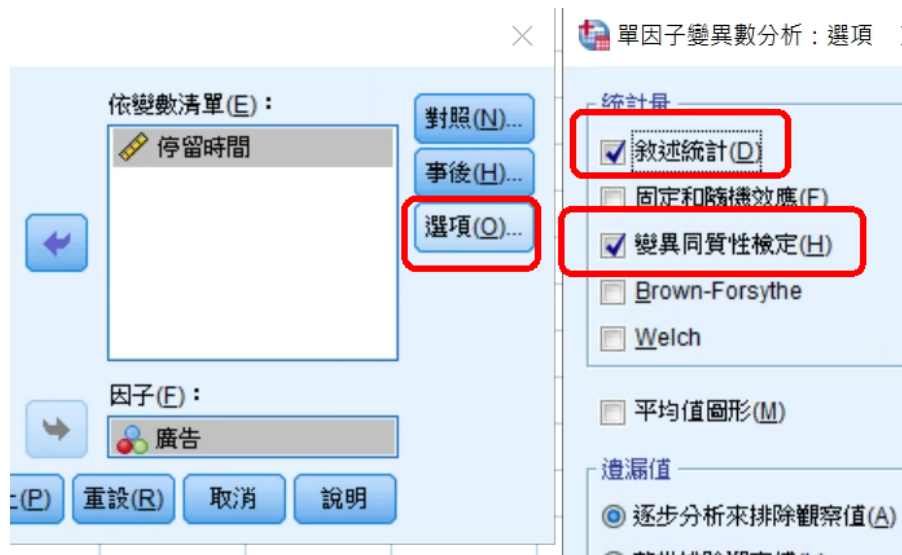
3. In the pop-up window:

- o Place the continuous variable in "Dependent List"
- o Place the categorical variable in "Factor"



4. Click the [Options] button on the right

- o Check "Homogeneity of variance test"
- o You can also check "Descriptive"



📋 Interpretation of Output Results (Levene's Test):

In the SPSS output table, you will see a section labeled: **Test of Homogeneity of Variances**

Which includes:

- F value, df1, df2, Sig. (p-value)

變異數同質性檢定

停留時間

Levene 統計量	自由度 1	自由度 2	顯著性
6.059	2	537	.003

🧠 判讀原則：

Levene's Test 結果	判斷	說明
$p \geq 0.05$	變異數相等 (等變異)	可使用 One-Way ANOVA
$p < 0.05$	變異數不等 (不齊性)	不宜使用傳統 ANOVA，建議改用 Welch ANOVA

Conclusion: Because the significance p-value is $0.003 < 0.05$,
Therefore, it indicates: variances are unequal, ANOVA cannot be used,
Welch ANOVA must be used

(5). [SPSS Implementation]: Welch ANOVA Test

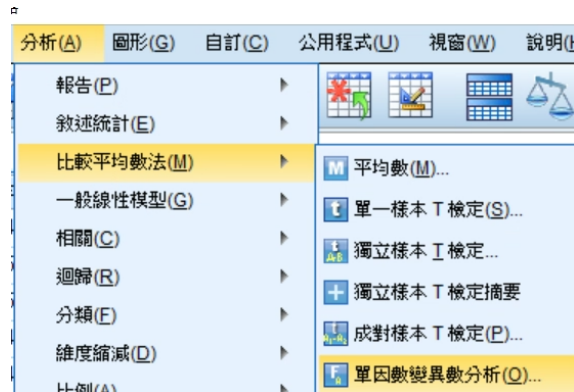
SPSS provides Welch ANOVA as an option for One-Way ANOVA.

Steps

1. Open SPSS and Load Data

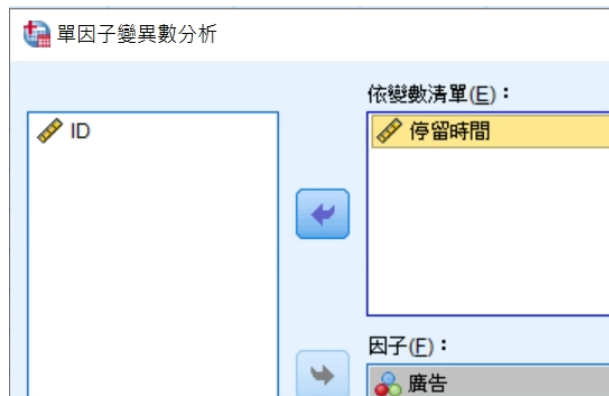
2. Select Welch ANOVA

- o Click Analyze → Compare Means → One-Way ANOVA.



3. Set Variables

- o Dependent List: Select the continuous variable to be compared (e.g., test scores, income, etc.).
- o Factor: Select the categorical variable (e.g., groups).



4. Enable Welch Test

- o Click the Options button.
- o In the Statistics section, check Welch.



How to Interpret Welch ANOVA Results

In the output's "Robust Tests of Equality of Means" table:

- Welch test's p-value (Sig.)
 - o $p > 0.05$: No significant difference between groups.
 - o $p \leq 0.05$: At least one group's mean is significantly different from the others.

平均值等式穩健檢定

停留時間

	統計量 ^a	自由度 1	自由度 2	顯著性
Welch	18.801	2	353.128	.000

a. 漸近分佈 F 值。

Conclusion: Because the significance p-value is $0.00 < 0.05$, Therefore, it indicates: at least one group's mean is significantly different from the others

(6). [Implementation]: [Post-hoc Test: Games-Howell]

- o Games-Howell Post-hoc Test
- o If the Welch test is significant, it is recommended to use the

Games-Howell test for multiple comparisons (suitable when variances are unequal).

How to Perform the Games-Howell Test in SPSS

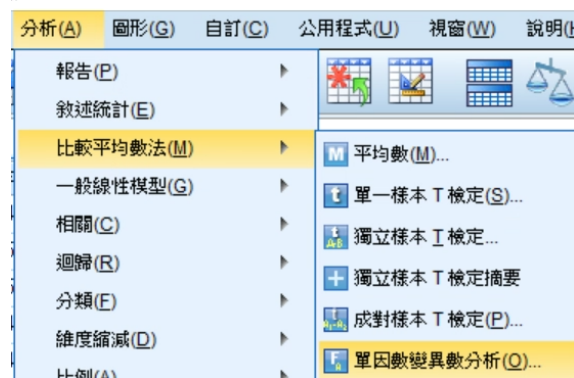
The Games-Howell post-hoc test can be performed through One-Way ANOVA.

Steps

1. Open SPSS and Load Data

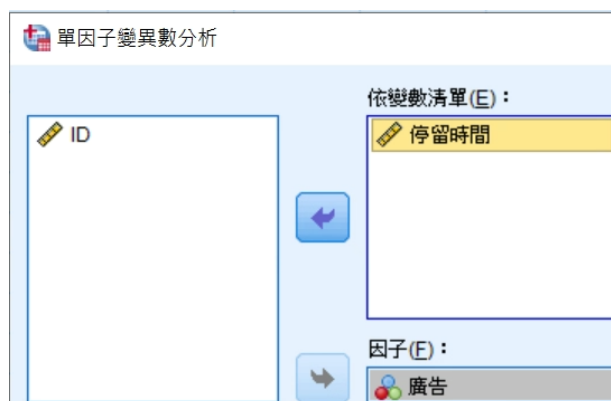
2. Select One-Way ANOVA

- Click Analyze → Compare Means → One-Way ANOVA.



3. Select Variables

- Dependent List:** Select the numerical variable to be compared (e.g., scores, measurements).
- Factor:** Select the categorical variable used for grouping (e.g., different groups).



4. Enable Games-Howell Post-hoc Test

- Click the Post Hoc button.
- In the Equal Variances Not Assumed area, check Games-Howell.
- If you are unsure whether the variances are equal, it is recommended to check both Tukey (suitable for equal variances) and Games-Howell (suitable for unequal variances).



How to Interpret SPSS Games-Howell Test Results

SPSS will output a "Multiple Comparisons" table, where:

- **Mean Difference:** Shows the mean difference between two groups.
- **Std. Error:** Estimated error.
- **Sig. (Significance p-value):**
 - $p > 0.05$: No significant difference between the two groups.
 - $p \leq 0.05$: There is a significant difference between the two groups.

多重比較

依變數：停留時間

Games-Howell 檢定

(I) 廣告	(J) 廣告	平均值差異 (I-J)	標準誤	顯著性	95% 信賴區間	
					下限	上限
廣告1	廣告2	4.68167 [*]	1.30763	.001	1.6031	7.7603
	廣告3	6.82050 [*]	1.13391	.000	4.1518	9.4892
廣告2	廣告1	-4.68167 [*]	1.30763	.001	-7.7603	-1.6031
	廣告3	2.13883	1.33413	.246	-1.0018	5.2794
廣告3	廣告1	-6.82050 [*]	1.13391	.000	-9.4892	-4.1518
	廣告2	-2.13883	1.33413	.246	-5.2794	1.0018

*. 平均值差異在 0.05 層級顯著。

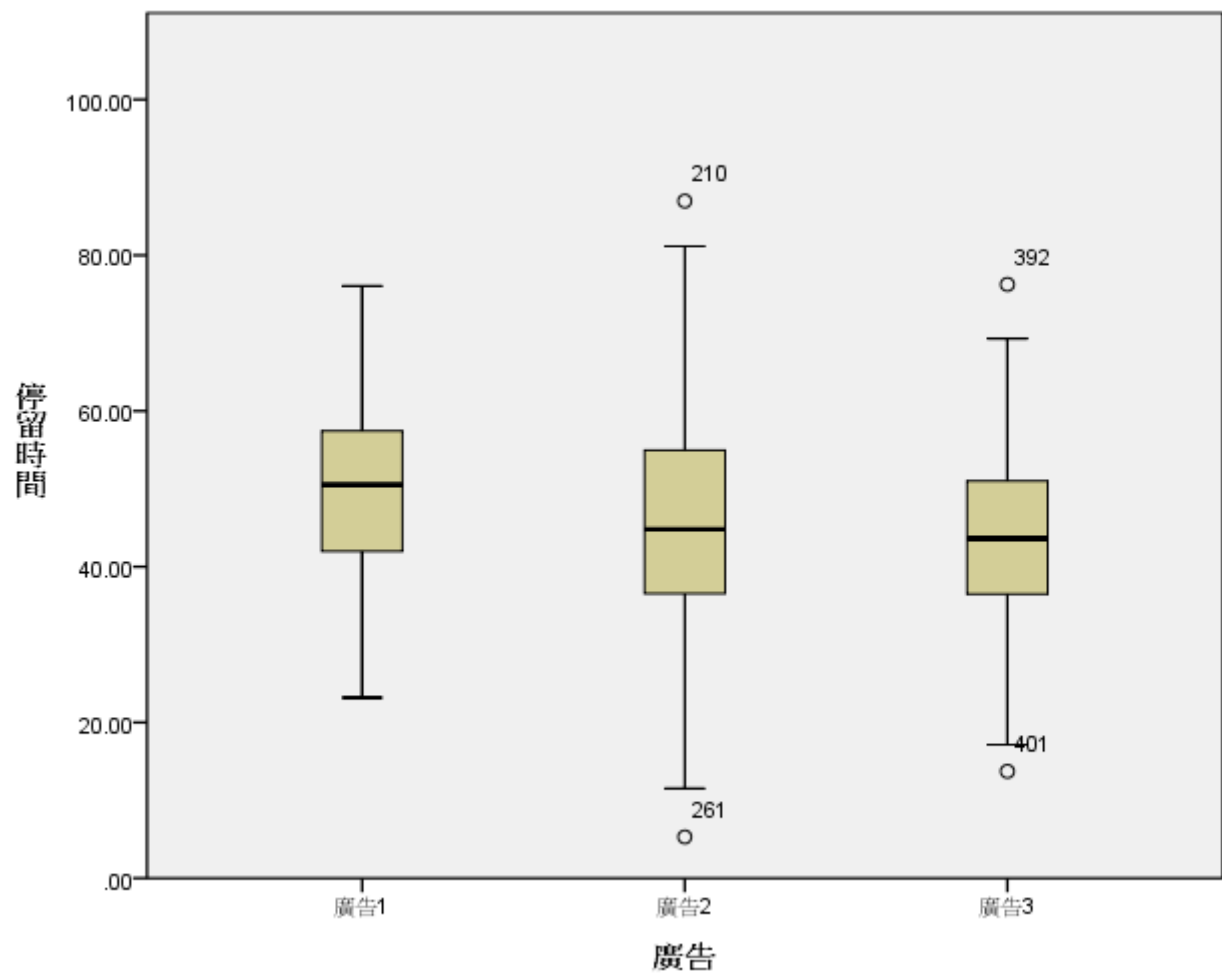
Conclusion 1: Ad 1 vs. Ad 2, significance p-value $0.001 < 0.05$, there is a significant difference between the 2 groups

Conclusion 2: Ad 1 vs. Ad 3, significance p-value $0.001 < 0.05$, there is a significant difference between the 2 groups

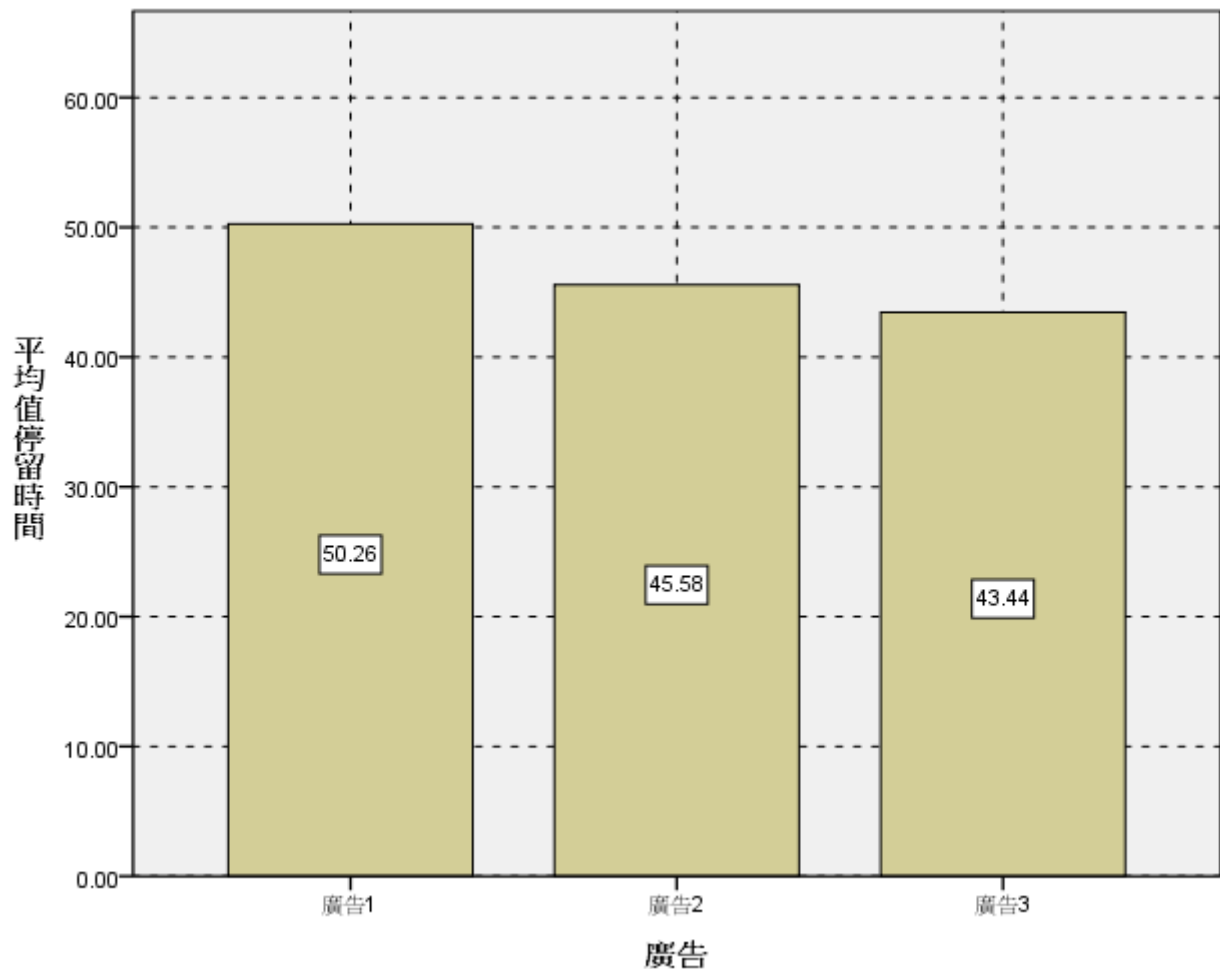
Conclusion 1: Ad 2 vs. Ad 3, significance p-value $0.246 > 0.05$, there is no significant difference between the 2 groups

比較組別 (I vs. J)	平均差異 (I-J)	p 值	顯著性	解釋
廣告1 vs 廣告2	4.68167	.001	✓ 顯著	廣告1的「停留時間」顯著高於廣告2
廣告1 vs 廣告3	6.82050	.000	✓ 顯著	廣告1的「停留時間」顯著高於廣告3
廣告2 vs 廣告3	2.13883	.246	✗ 不顯著	廣告2與廣告3的「停留時間」差異不顯著

(7). [Plotting]: Box Plot



(8). [Plotting]: Bar Chart



(9). Conclusion:

1. "Ad 1" has the highest appeal (significantly longer dwell time)
2. There is no significant difference between "Ad 2 and Ad 3"
3. It can be concluded that "ad content design" significantly affects customer dwell behavior, especially the difference between Ad 1 and the others is most obvious