

```

dm'log;clear;output;clear';
options ps=512 ls=99 nocenter nodate nonumber
        nolabel FORMCHAR="|----|+|----+=|/\<>*" ;

ODS LISTING;

*** Table 23.2 *****;
*** Moore, David S. Essential Statistics, 1st Ed. 2010, ***;
*** W. H. Freeman & Co. NY, NY ***;
*** Time in minutes customers stay in a restaurant when ***;
*** varous odors are present ***;
*****;

TITLE1 'Analysis of Variance (One-way ANOVA)';

data odors; infile cards missover;
  infile 'Odor attraction.csv' missover DSD dlm="," firstobs=2;
  TITLE2 'Time customers stay in a restaurant exposed to odors';
  LABEL odor = 'Odor used in experiment'
        time = 'Time in minutes';
  input odor $ time;
datalines;
;
ODS PDF style=minimal body='Odor attraction boxplot.PDF' ;
proc sort data=odors; by odor; run;
proc boxplot data=odors; plot time * odor; run;

ods PDF close;
ODS HTML style=minimal body='Odor attraction ANOVA CRD.html' ;

proc print data=odors; var odor Time;
  TITLE3 'Raw data list (unsorted)'; run;

proc mixed data=odors order=data; class odor;
  TITLE3 'ANOVA with PROC MIXED';
  model Time = odor / DDFM = KR;
  repeated / group = odor;
run;

proc mixed data=odors order=data; class odor;
  TITLE3 'ANOVA with PROC MIXED - separate variances';
  model Time = odor / DDFM=KR outp=resids;
  lsmeans odor / adjust=tukey pdiff;
  ods output diffs=ppp lsmeans=mmm;
  *ods listing exclude diffs lsmeans; * this line is inactive;
run;
TITLE4 'Post hoc adjustment with macro by Arnold Saxton';
* SAS Macro by Arnold Saxton: Saxton, A.M. 1998. A macro for
* converting mean separation output to letter odorings in Proc Mixed.
* In Proc. 23rd SAS Users odor Intl., SAS Institute, Cary, NC, pp1243-1246.;
%include 'C:\pdmix800.sas';
%pdmix800(ppp,mmm,alpha=0.05,sort=yes);
run;

proc univariate data=resids normal plot; var resid;
  TITLE4 'Univariate analysis of residuals';
  TITLE5 'Test of normality and plots only';
  ods exclude Moments BasicMeasures ExtremeObs ExtremeValues
        Modes MissingValues Quantiles TestsForLocation;
  histogram resid / normal;
run;

```

```
quit;

ods html close;

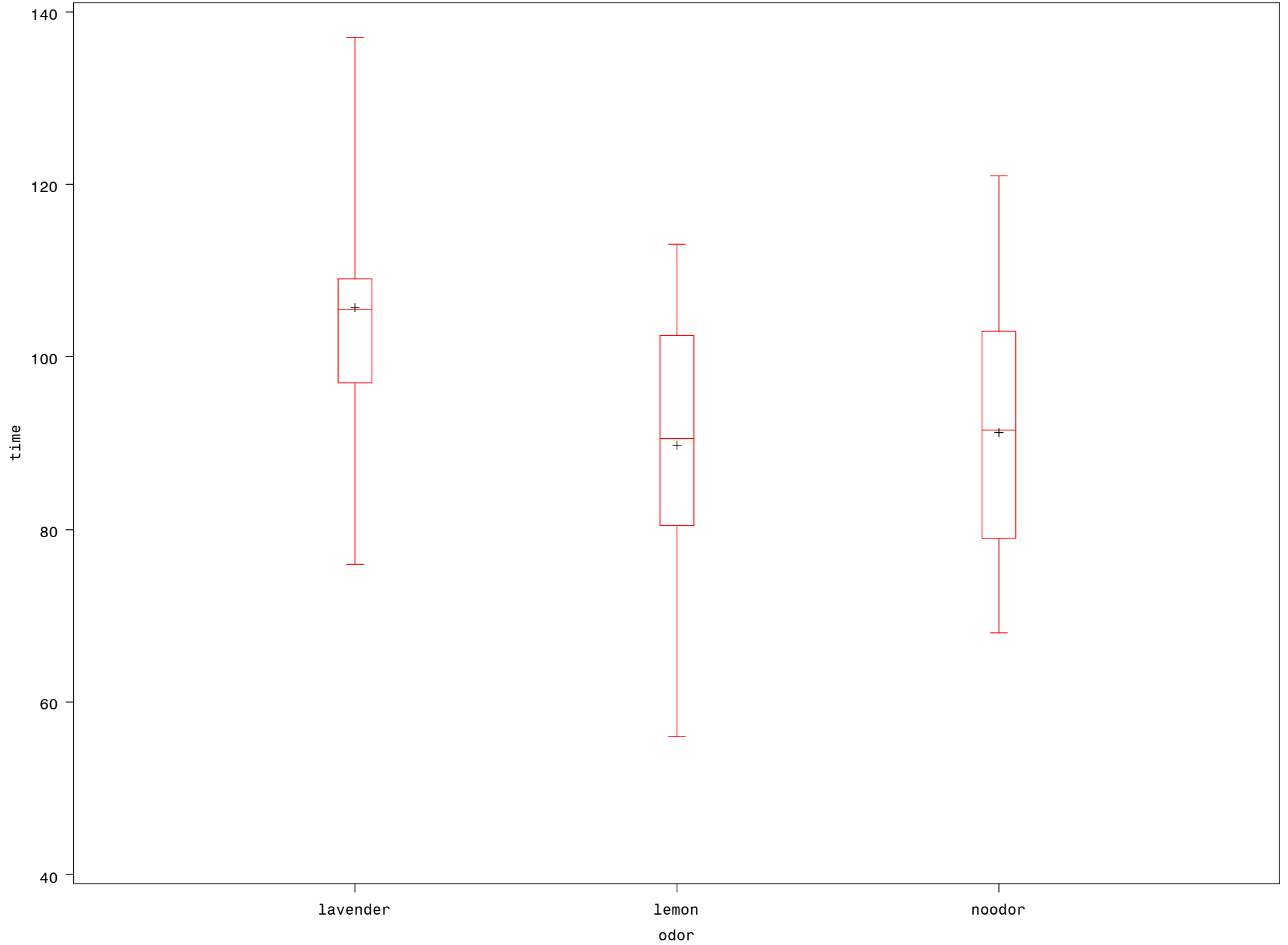
run;
quit;
```

Analysis of Variance (One-way ANOVA)

Time customers stay in a restaurant exposed to odors
Raw data list (unsorted)

Obs	odor	time	44	lemon	63
			45	lemon	83
1	lavender	92	46	lemon	108
2	lavender	126	47	lemon	91
3	lavender	114	48	lemon	88
4	lavender	106	49	lemon	83
5	lavender	89	50	lemon	106
6	lavender	137	51	lemon	108
7	lavender	93	52	lemon	60
8	lavender	76	53	lemon	96
9	lavender	98	54	lemon	94
10	lavender	108	55	lemon	56
11	lavender	124	56	lemon	90
12	lavender	105	57	lemon	113
13	lavender	129	58	lemon	97
14	lavender	103	59	noodor	103
15	lavender	107	60	noodor	68
16	lavender	109	61	noodor	79
17	lavender	94	62	noodor	106
18	lavender	105	63	noodor	72
19	lavender	102	64	noodor	121
20	lavender	108	65	noodor	92
21	lavender	95	66	noodor	84
22	lavender	121	67	noodor	72
23	lavender	109	68	noodor	92
24	lavender	104	69	noodor	85
25	lavender	116	70	noodor	69
26	lavender	88	71	noodor	73
27	lavender	109	72	noodor	87
28	lavender	97	73	noodor	109
29	lavender	101	74	noodor	115
30	lavender	106	75	noodor	91
31	lemon	78	76	noodor	84
32	lemon	104	77	noodor	76
33	lemon	74	78	noodor	96
34	lemon	75	79	noodor	107
35	lemon	112	80	noodor	98
36	lemon	88	81	noodor	92
37	lemon	105	82	noodor	107
38	lemon	97	83	noodor	93
39	lemon	101	84	noodor	118
40	lemon	89	85	noodor	87
41	lemon	88	86	noodor	101
42	lemon	73	87	noodor	75
43	lemon	94	88	noodor	86

Analysis of Variance (One-way ANOVA)
Time customers stay in a restaurant exposed to odors



Analysis of Variance (One-way ANOVA)
 Time customers stay in a restaurant exposed to odors
 ANOVA with PROC MIXED

The Mixed Procedure

Model Information

Data Set	WORK.ODORS
Dependent Variable	time
Covariance Structure	Variance Components
Group Effect	odor
Estimation Method	REML
Residual Variance Method	None
Fixed Effects SE Method	Kenward-Roger
Degrees of Freedom Method	Kenward-Roger

Class Level Information

Class	Levels	Values
odor	3	lavender lemon noodor

Dimensions

Covariance Parameters	3
Columns in X	4
Columns in Z	0
Subjects	88
Max Obs Per Subject	1

Number of Observations	
Number of Observations Read	88
Number of Observations Used	88
Number of Observations Not Used	0

Iteration History

Iteration	Evaluations	-2 Res Log Like	Criterion
0	1	705.99570723	
1	1	705.16851289	0.00000000

Convergence criteria met.

Covariance Parameter Estimates

Cov Parm	Group	Estimate
Residual	odor lavender	171.73
Residual	odor lemon	238.32
Residual	odor noodor	222.89

FitStatistics

-2 Res Log Likelihood	705.2
AIC (smaller is better)	711.2
AICC (smaller is better)	711.5
BIC (smaller is better)	718.6

Null Model Likelihood Ratio Test

DF	Chi-Square	Pr > ChiSq
2	0.83	0.6613

Type 3 Tests of Fixed Effects

	Num	Den		
Effect	DF	DF	F Value	Pr > F
odor	2	55.3	11.73	<.0001

Analysis of Variance (One-way ANOVA)

Time customers stay in a restaurant exposed to odors
ANOVA with PROC MIXED - separate variances

The Mixed Procedure

Model Information

Data Set	WORK.ODORS
Dependent Variable	time
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information

Class	Levels	Values
-------	--------	--------

odor	3	lavender lemon noodor
------	---	-----------------------

Dimensions

Covariance Parameters	1
Columns in X	4
Columns in Z	0
Subjects	1
Max Obs Per Subject	88

Number of Observations

Number of Observations Read	88
Number of Observations Used	88
Number of Observations Not Used	0

Covariance Parameter

Estimates

Cov Parm	Estimate
Residual	210.34

FitStatistics

-2 Res Log Likelihood	706.0
AIC (smaller is better)	708.0
AICC (smaller is better)	708.0
BIC (smaller is better)	710.4

Type 3 Tests of Fixed Effects

Effect	Num		Den	F Value	Pr > F
	DF	DF			
odor	2	85		10.86	<.0001

Least Squares Means

Effect	odor	Estimate	Standard Error	DF	t Value	Pr > t
odor	lavender	105.70	2.6479	85	39.92	<.0001
odor	lemon	89.7857	2.7408	85	32.76	<.0001
odor	noodor	91.2667	2.6479	85	34.47	<.0001

Differences of Least Squares Means

Effect	odor	_odor	Estimate	Standard Error	DF	t Value	Pr > t	Adjustment	Adj P
odor	lavender	lemon	15.9143	3.8110	85	4.18	<.0001	Tukey-Kramer	0.0002
odor	lavender	noodor	14.4333	3.7447	85	3.85	0.0002	Tukey-Kramer	0.0007
odor	lemon	noodor	-1.4810	3.8110	85	-0.39	0.6985	Tukey-Kramer	0.9202

Analysis of Variance (One-way ANOVA)
 Time customers stay in a restaurant exposed to odors
 ANOVA with PROC MIXED - separate variances
 Post hoc adjustment with macro by Arnold Saxton

Effect=odor ADJUSTMENT=Tukey-Kramer(P<0.05) bygroup=1

Obs	odor	Estimate	StdErr	MSGROUP
1	lavender	105.70	2.6479	A
2	noodor	91.2667	2.6479	B
3	lemon	89.7857	2.7408	B

Analysis of Variance (One-way ANOVA)
 Time customers stay in a restaurant exposed to odors
 ANOVA with PROC MIXED - separate variances
 Univariate analysis of residuals
 Test of normality and plots only

The UNIVARIATE Procedure
 Variable: Resid

Tests for Normality

Test	--Statistic--	-----p Value-----
Shapiro-Wilk	W 0.989678	Pr < W 0.7211
Kolmogorov-Smirnov	D 0.056696	Pr > D >0.1500
Cramer-von Mises	W-Sq 0.048667	Pr > W-Sq >0.2500
Anderson-Darling	A-Sq 0.281573	Pr > A-Sq >0.2500

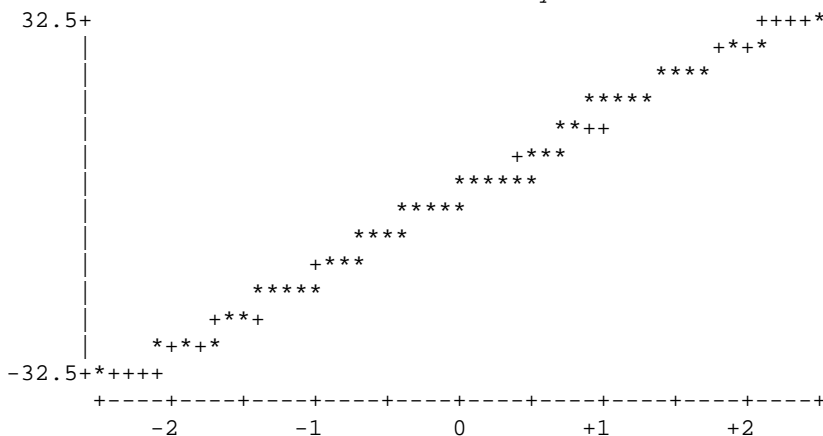
Stem Leaf Boxplot

3	01	2	
2	7	1	
2	02334	5	
1	5556668888	10	
1	00124	5	+-----+
0	567778	6	
0	0001111122233344	16	*---+---*
-0	444322221110	12	
-0	987777655	9	
-1	432221	6	+-----+
-1	9988776655	10	
-2	32	2	
-2	7	1	
-3	400	3	

-----+-----+-----+-----+

Multiply Stem.Leaf by 10**+1

Normal Probability Plot



Analysis of Variance (One-way ANOVA)
 Time customers stay in a restaurant exposed to odors
 ANOVA with PROC MIXED - separate variances
 Univariate analysis of residuals
 Test of normality and plots only

The UNIVARIATE Procedure
 Fitted Normal Distribution for Resid

Parameters for Normal Distribution

Parameter	Symbol	Estimate
Mean	Mu	0
Std Dev	Sigma	14.33542

Goodness-of-Fit Tests for Normal Distribution

Test	Statistic	p Value
Kolmogorov-Smirnov	D = 0.05669585	Pr > D > 0.150
Cramer-von Mises	W-Sq = 0.04866711	Pr > W-Sq > 0.250
Anderson-Darling	A-Sq = 0.28157273	Pr > A-Sq > 0.250

Quantiles for Normal Distribution

Percent	Quantile	
	Observed	Estimated
1.0	-33.78571	-33.3492
5.0	-23.26667	-23.5797
10.0	-18.26667	-18.3716
25.0	-9.70000	-9.6691
50.0	0.25714	0.0000
75.0	10.01667	9.6691
90.0	18.30000	18.3716
95.0	23.30000	23.5797
99.0	31.30000	33.3492