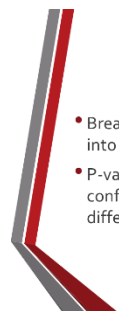


## Analysis of Variance

- Breaks down variability into sources
- P-value = probability or confidence that no differences exist
- Assumptions:
  - Homogeneity of variance
  - Normal distribution
  - Independence of errors
  - Additivity

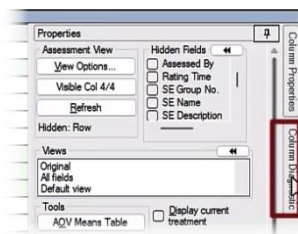
[gdmdata.com/Resources/Video-Tutorials/Statistics-and-ARM-Overview](http://gdmdata.com/Resources/Video-Tutorials/Statistics-and-ARM-Overview)



Data Review is the process of preparing assessment data to be analyzed and reported. In this video we demonstrate the basics of reviewing data in ARM.

Analysis of Variance (or AOV) is commonly used for data analysis, so our focus for data review is on AOV. Specifically, to address whether the data fit the assumptions of this analysis. We introduced the AOV method and its assumptions in a previous video – it is recommended to review that presentation before proceeding with this content.

The primary tool for data review in ARM is the Column Diagnostics panel. This can be opened from the Assessment Data editor. On the far-right edge of the window, a box titled Column Diagnostics opens this tool. (Hide the regular Properties panel and expand this panel to view the full content).



Column 1 Diagnostics

**Diagnostics**

Include spatial models

Raw Graphs  
Show... Layout: 4 X 2

Statistics (P)	Raw	<input checked="" type="checkbox"/> IID	<input type="checkbox"/> AL	<input type="checkbox"/> AS	<input type="checkbox"/> AR
N	24	24	24	24	24
Unique	23	24	24	24	24
Analyzed	24	24	24	24	24
Missing	0	0	0	0	0
Empty	0	0	0	0	0
Excluded	0	0	0	0	0

Column Diagnostics displays data review details for the assessment column where the cursor is. The top section is the Diagnostics table with descriptive statistics of the assessment data, across various potential actions or transformations available for the data.

The first few rows of this table are essentially *attributes* of the data, used more in the data confirmation step. These attributes describe how many data points are included in the analysis and how many are missing for various reasons.

Our main focus is these four rows, which are tests for the assumptions of AOV. The table displays the p-value result of each test, so when the value is significant (smaller than your alpha level) then we have an assumption (or problem) to address!

Column 1 Diagnostics

**Diagnostics**

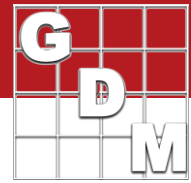
Include spatial models

Raw Graphs  
Show... Layout: 4 X 2

Statistics (P)	Raw	<input checked="" type="checkbox"/> IID	<input type="checkbox"/> AL	<input type="checkbox"/> AS	<input type="checkbox"/> AR
Treatments	6	6	6	6	6
Levene's	0	0.02	0.572	0.432	.
Shapiro-Wilk	0.0	0.341	0.048	0.128	.
Skewness	0.006	0.434	0.071	0.134	.
Kurtosis	0.178	0.707	0.605	0.94	.
MaxStdRes	.	1.719	1.938	2.009	2.233

We use the "IID" column to determine if any action is necessary for this data. The IID column is calculated on the **residuals** of the data, not the "raw" data points themselves.

Here in assessment 1 most tests pass, except for the Levene's test. This indicates *heterogeneity* of variance, a departure from the AOV assumptions. So how do we meet the assumptions of AOV?



**Recommendations**

Basis: Assessment Values

AL Graphs: Show... Layout: 4 X 2

Code	Test Statistic	Value	Comment
1	AL Levene's	3.574	Transform to stabilize variance
2	IID Shapiro-Wilk	0.955	Does not fail general test of normality of residuals
3	IID Skewness	0.399	Does not fail test of skewness of residuals
4	IID Kurtosis	0.37	Does not fail test of excess kurtosis of residuals

The Recommendations table provides a summary of the four assumption tests, and makes a recommendation for the action needed, if any. For the tests that did not fail, the code 'IID' is listed to indicate that no action is necessary. (IID stands for "Identically and Independently Distributed".)

**Recommendations**

Basis: Assessment Values

AL Graphs: Assessment Values

Show... Rating Type : COUDIS  
Rating Unit/Min/Max : NUMBER

Code	Test Statistic	Value	Comment
1	AS Levene's	3.574	Transform to stabilize variance
2	IID Shapiro-Wilk	0.955	Does not fail general test of normality of residuals
3	IID Skewness	0.399	Does not fail test of skewness of residuals
4	IID Kurtosis	0.37	Does not fail test of excess kurtosis of residuals

In this column, the logarithm transformation AL successfully corrects the heterogeneity of variance. But if we check the Diagnostics table above, we can see that both AL *and* AS work, so which should we choose?

The **Basis** option tells ARM what to consider when making recommendations. The option 'Assessment Values' looks only at the numbers and chooses a transformation that works. But ARM can consider the *type* of data that is entered, to make a better recommendation.

**Recommendations**

Basis: Rating Type : COUDIS

AS Graphs: Show... Layout: 4 X 2

Code	Test Statistic	Value	Comment
1	AS Levene's	3.574	Transform to stabilize variance
2	IID Shapiro-Wilk	0.955	Does not fail general test of normality of residuals
3	IID Skewness	0.399	Does not fail test of skewness of residuals
4	IID Kurtosis	0.37	Does not fail test of excess kurtosis of residuals

If we select Rating Type as the basis, ARM now knows that this is count data, and the recommendation changes to AS! The square root transformation is more appropriate for counts of a "rare event" like diseased plants.

Assessment Data - Line 53

Column Number	1
Pest Type	D Disease
Plant-Eval Interval	21 DP-1
ARM Action Codes	AS

+	Sub	Rep	Blk	Col	Plot	Tit	
	1	1	1	1	101	2	68
	1	1	1	2	102	4	55
	1	1	1	3	103	5	12
	1	1	1	4	104	1	165

To accept the proposed transformation, double-click on the recommendation in the table, and AS is added to the ARM Action Codes field in this assessment column.

Note that this does not change any of the entered data. Instead, these codes are *instructions* for when the analysis is performed.

**Recommendations**

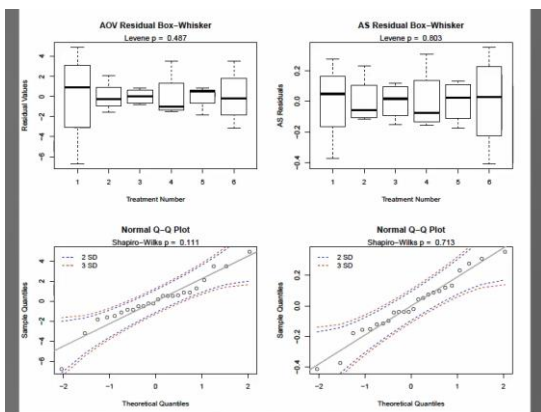
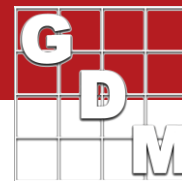
Basis: Rating Type : COUPLA

IID Graphs: Show... Layout: 4 X 2

Code	Test Statistic	Value	Comment
1	IID Levene's	0.536	Does not fail test of homogeneity of variances ar
2	IID Shapiro-Wilk	0.961	Does not fail general test of normality of residuals
3	IID Skewness	0.293	Does not fail test of skewness of residuals
4	IID Kurtosis	0.856	Does not fail test of excess kurtosis of residuals

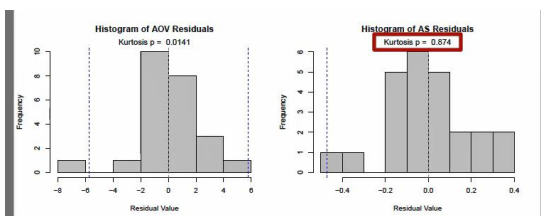
Repeat this process with each assessment column to be analyzed.

In this assessment, the recommended action is IID for all of the tests. This is the way to indicate that you have reviewed the data, but no corrections were necessary. Also, this is a way to "sign-off" that the data is reviewed and ready for analysis and reporting.



For a deeper look at the data, view diagnostic graphs by clicking 'Show'.

On the left are graphs for the residuals, used to visualize departures from the AOV assumptions. On the right are graphs for the recommended action, to confirm the issue is resolved.



There is a graph for each of the tests from the Recommendations table. For this assessment, Kurtosis was significant in the residuals, but we can see that the Square Root transformation resolves this issue without breaking any of the other assumptions. So, we can accept the recommendation for this assessment column.

Diagnostics						
Statistics (P)	Raw	<input checked="" type="checkbox"/> IID	<input type="checkbox"/> AL	<input type="checkbox"/> AS	<input type="checkbox"/> AA	<input type="checkbox"/> AR
Treatments	6	6	6	6	6	6
Levene's	0.041	0.268	0.637	0.735	0.744	
Shapiro-Wilk	0	0.021	0	0.004	0.001	
Skewness	0.001	0.863	0.001	0.083	0.02	
Kurtosis	0.024	0.011	0	0.009	0.0	

Recommendations			
Code	Test Statistic	Value	Comment
1	IID	Levene's	1.411 Does not fail test of homogeneity of variances among
2	AR	Shapiro-Wilk	0.9 Available transformations do not improve normality
3	IID	Skewness	0.087 Does not fail test of skewness of residuals
4	AR	Kurtosis	2.709 Available transformations do not correct kurtosis of res

The last assessment in our example has a different kind of recommendation. None of the transformations resolve the failed Shapiro-Wilks test for normality, so the action "AR" is recommended instead. This performs a *non-parametric* analysis in place of AOV for this assessment column.

Rating Type	COUPLA	DILOGR	LODGIN
Rating Unit	NUMBER	%	%
Rating Min/Max/Interval		0, 100, -	0, 100, -
Crop Type, Code	C, ZEAMD	C, ZEAMD	C, ZEAMD
Pest Code		PHYTHB	
Trt-Eval Interval	43 DA-A	71 DA-A	182 DA-A
ARM Action Codes	IID	AS	AR
Trt No.	2*	3* dAS	4*
1			20.3 a
2			3.3 b
3	73.8 ab	17.0 c	0.0 c
4	70.0 b	20.0 bc	0.0 c
5	74.8 a	13.0 d	0.0 c
6	72.0 ab	13.9 d	0.0 c
LSD P=.05	3.00	0.35	0.00
Standard Deviation	2.3		2.69
CV			
Levene's Prob(F)	0.74		0.268
P(Shapiro-Wilk)	0.4623	0.7131	0.0213*

Non-parametric statistics do not have the same assumptions as Analysis of Variance, and so is the preferred alternative when those requirements cannot be met. Although ranks are used to analyze the data, mean separation tests can still be run on the mean of the ranks, and so the results are presented very similar for "AR" assessment columns on the AOV Means Table report.