



LEAN
SOLUTIONS
ACADEMY

A photograph of three business professionals in an office setting. A woman in a white blouse and black scarf is seated on the left, smiling. Another woman in a light blue shirt is leaning over her from the center, also smiling. A man in a light blue shirt is seated on the right, looking towards the women. The image is overlaid with a dark blue geometric shape containing the title text.

Lean Six Sigma Training **Black Belt**

brought to you by:



Measurement System Analysis

For Attribute Data

Attribute Measurement Error Analysis

Sometimes it is not convenient to measure the characteristics of interest numerically. For example how do you measure “must be comfortable to wear”?

In situations such as this, testing is opinion based and is subjective.

SigmaXL and some other stats packages offer tests for measurement systems based on subjective opinions

Is this Pizza really tasty ?



Attribute Measurement Error Analysis

- Attribute data is classifications rather than number measures
 - “Binary” data type is an example of Attribute data
- Unlike a numeric testing, an attribute test does not give information on the quality of a part but only indicates whether the part meets the stated criteria or not.
 - This decision can be based on a set of specified standards

Two attribute tests:

- Attribute Gauge R&R test
 - Attribute gage studies assess the amount of bias and repeatability of a gage when the response is a binary attribute variable.
- Attribute Agreement Analysis
 - (to assess the consistency and correctness of subjective ratings):
 - Within appraisers, when each appraiser rates each item more than once
 - Between appraisers
 - Against the standard, when you have a known rating for each part

Walkthrough of Attribute Agreement Analysis

A Food manufacturer decides to evaluate if a product is correctly wrapped on a 1-5 scale. Four members of the team volunteer to perform appraisals for the projects

Each makes two evaluations on each one of 30 sample sweets

A SigmaXL Gauge R&R worksheet is created to hold the data

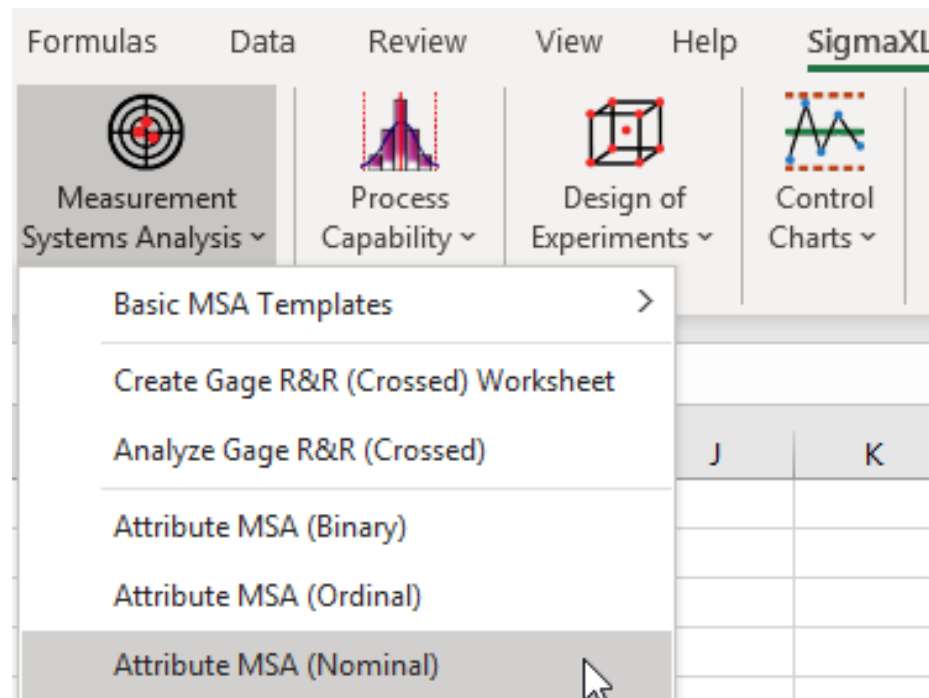
Because the correct value of each sample is known (this has previously been established) this data is entered into it's own column

A	B	C	D	E	F	G	H	I
Appraiser	Response	Sample	Trial	Standard				
Tom	5	1	1	5				
Tom	5	1	2	5				
Tom	3	2	1	3				
Tom	3	2	2	3				
Tom	1	3	1	1				
Tom	1	3	2	1				
Tom	2	4	1	2				
Tom	2	4	2	2				
Tom	1	5	1	1				

This worksheet is available in your SigmaXL Data folder – go to the MSA tab

Locating Attribute Agreement Analysis

SigmaXL → Measurement Systems Analysis → Attribute MSA (Nominal)



Configuring the Test

The appropriate columns are identified as is the column containing the known value (standard)

Attribute MSA (Nominal) ✕

Trial	<u>P</u> art/Sample >>	Sample	OK >> Cancel Help
	<u>A</u> ppraiser >>	Appraiser	
	<u>A</u> ssessed Result >>	Response	
	<u>T</u> rue Standard (Optional) >>	Standard	
	<< Remove		

☐ Report Information (Optional)	Confidence Level 95.0
Product/Unit Name: Performed By: Date: Notes:	Percent Confidence Interval Type: ☐ <u>W</u> ilson Score ☒ <u>E</u> xact

Text Output

- The results tab gives a detailed textual analysis of the investigation there are a number of categories:
 - Within appraisers
 - Each Appraiser vs Standard
 - Between Appraisers
 - All Appraisers vs Standard

Attribute Agreement Report:

Within Appraiser Agreement	# Inspected	# Matched	Percent	95.0% LC (Exact)	95.0% UC (Exact)	Fleiss' Kappa Overall Response
Lizzy	50	50	100.00	94.18	100.00	1.0000
Matt	50	43	86.00	73.26	94.18	0.8235
Phoebe	50	48	96.00	86.29	99.51	0.9496
Tom	50	45	90.00	78.19	96.67	0.8747

Each Appraiser vs. Standard Agreement	# Inspected	# Matched	Percent	95.0% LC (Exact)	95.0% UC (Exact)	Fleiss' Kappa Overall Response
Lizzy	50	47	94.00	83.45	98.75	0.9248
Matt	50	41	82.00	68.56	91.42	0.8616
Phoebe	50	46	92.00	80.77	97.78	0.9248
Tom	50	45	90.00	78.19	96.67	0.9373

Tests Used by SigmaXL

- So long as each appraiser assesses each unit more than once, Minitab will run several tests to investigate the consistency of each appraiser – between their own scores for each piece or unit, and between the appraisers as a group for each piece or unit
- The 2 most well known tests are:
 - **Fleiss' Kappa statistics**
 - **Kendall's Coefficient of Concordance**

Details on the next two slides ...

What Each Test Does

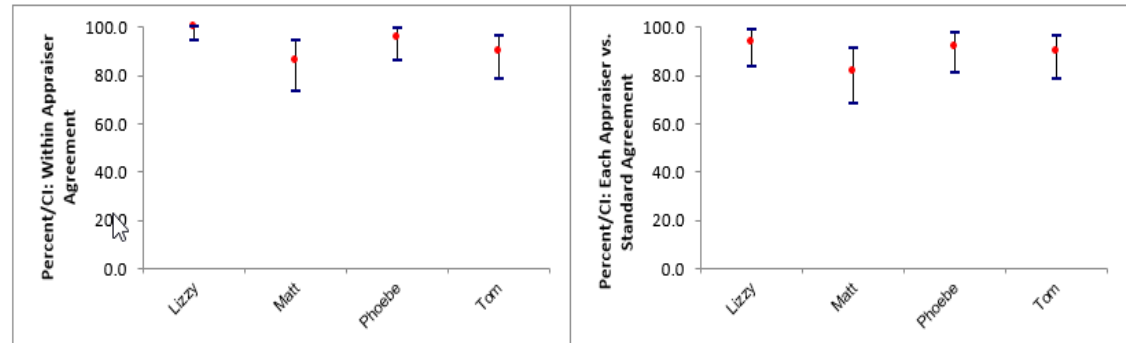
Test	What it does ...
Fleiss' Kappa Statistics	Measures agreement between appraisers Group consistency Tests whether the appraisers agree with each other when making an assessment: Ho: Any agreement between appraisers is due to random chance Ha: Any agreement between appraisers is NOT likely to be due to random chance
Kendall's Correlation Coefficient	Measures individual consistency Tests whether individual appraisers constantly assess each item the same: Ho: There is no association among multiple ratings made by an appraiser Ha: The ratings are associated with one another

“Indicators” Used by the Tests

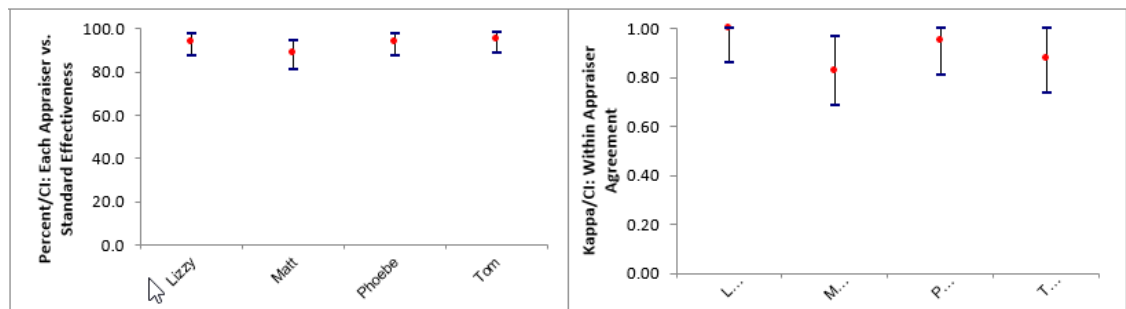
Test	What it does ...
Fleiss’ Kappa value	If kappa = 1, then there is perfect agreement. If kappa = 0, the agreement is the same as would be expected by chance. Depending on the application, kappa less than 0.7 indicates that the measurement system needs improvement. kappa values greater than 0.9 are considered excellent. Look for a kappa value > 0.7. to check if the appraisers' rating consistency is within acceptable limits
Kendall's coefficient of concordance	Kendall's coefficient of concordance can range from 0 to 1. The higher the value of Kendall's, the less variance there is in an appraiser rankings (we are not saying they are correct only consistent)

Attribute Agreement - Graphical

- If you have multiple trials, then SigmaXL plots the percentage of assessment agreement within appraiser



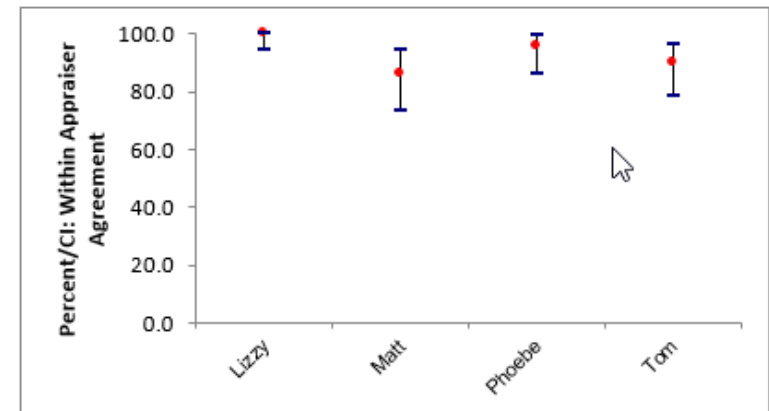
- If you have a known standard for each part, then the percent matched between appraiser and standard is plotted



See next slide for a description of this ...

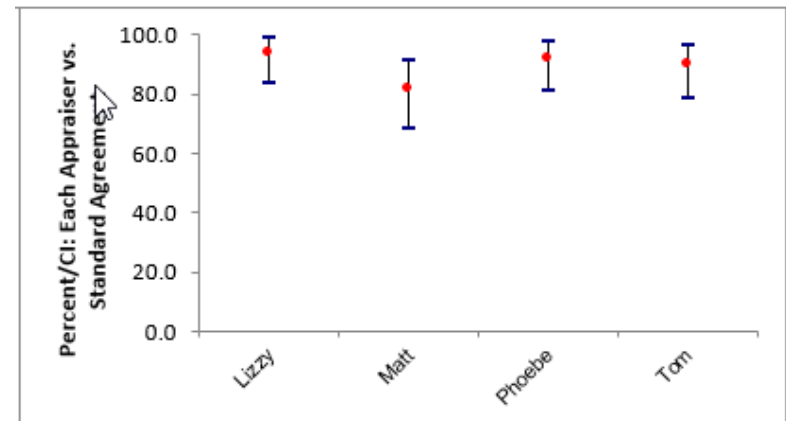
Graphs – Within Appraiser

- The Within Appraiser graphs show you the consistency of each operator's answers
- For each appraiser, the graph consists of the following:
 - Red circle, which provides the actual percent matched.
 - Blue line, which provides a 95.0% confidence interval for percent matched.
 - Blue lines, which provide the lower and upper limits for the 95.0% confidence interval, respectively.



Graphs – Appraiser vs Standard

- The Appraiser versus Standard graph shows the correctness of each operator's answers
- For each appraiser, the graph consists of the following:
 - Red circle, which provides the actual percent matched
 - Blue line, which provides a 95.0% confidence interval for percent matched
 - Blue lines, which provide the lower and upper limits for the 95.0% confidence interval, respectively



What Conclusions

Can we draw from this Attribute Measurement Error Analysis?

- The appraisers seem to be consistent in their measurements – both between the measurements they make and between themselves as a group
- They also seem to rate each piece correctly (when compared to an established standard)
- This accuracy is unlikely to have happened by chance
- So in conclusion it appears that the appraisers are doing a good job, they are accurate and precise in their ratings. There is variation between appraisers but not enough to cause concern.

Example of Attribute Agreement Analysis

Fabric appraisers at a textile printing company rate the print quality of cotton fabric on a 1 to 5 point scale. The Black Belt wants to assess the consistency and correctness of the appraisers' ratings. The Black Belt asks four appraisers to rate print quality on 50 samples of fabric twice, in random order.

Quality Scale 1  5



SigmaXL for Attribute Agreement Analysis

Open the sample data, TextilePrintQuality.xlsx.

1. Choose **Measurement Systems Analysis > Attribute MSA Nominal**
2. In **Part/Sample**, enter *Sample*.
3. In **Appraiser**, enter *Appraiser*.
4. In **True Standard**, enter *Standard*.
5. Click **OK**.

Answers

Binomial

1. a) 0.0823 or 8.23 % b) $1 - 0.9962 = 0.0038$ (0.38 %)
2. 0.349 (34,9 %)
3. a) 0.0282 2.28% b) 0.2668 26.7% c) 0.65 (65%)
4. 0.027 (2.7 %)

Its is VERY Unlikely it would win 3 out of 3 based on past performance !

Poisson

1. $\lambda = 1.65$ per page
 $\lambda = 4.95$ per three pages
Answer = 0.0071
2. $\lambda = 0.333$ Cumulative to 1 Answer = 0.9554
3. $\lambda = 2$ per 3 mins therefore $\lambda = 6$ per 9 minutes
Cumulative Prob up to 4 people with $\lambda = 6$ Answer = 0.285 or 28.5 %
4. a) $\lambda = 1.6$ b) Probability of 0.137828 or approx. 13.8%
5. $\lambda = 2$ Find Cumulative prob first then $1 - 0.676676 = 0.3233$ (32.33 %)

Good Luck With Your Black Belt Exam!

