Attribute Data

The concepts of R&R studies are the same for attribute data as for variable data, but the measurement of these is entirely different. The emphasis is on how capable or effective the appraiser is in detecting conforming or nonconforming parts repeatedly and how biased the appraiser is toward rejecting conforming parts or accepting nonconforming parts. The effectiveness of different appraisers can be compared when assessing reproducibility.

The measures used in the inspection capability study for attribute data are defined as follows:

Effectiveness (E): The ability to accurately detect conforming and nonconforming parts. This is expressed as a number between 0 and 1, where 1 is perfect, and is computed by:

E = Number of parts correctly identified/total opportunities to be correct

The total opportunities to be correct are a function of the number of parts used and how many times each part is inspected. If 10 parts are selected and each is inspected three times, there are a total of `3 x 10 = 30` opportunities to be correct.

Probability of a Miss (P_{miss}): The probability of a miss is the chance of not rejecting a nonconforming part. This is a serious type of error since a nonconforming part is accepted. The probability of a miss is computed by the following formula:

P_{miss} = number of misses/number of opportunities for a miss

The number of opportunities for a miss is a function of the number of nonconforming parts used in the study and the number of times each part is inspected. If five nonconforming parts are used and each part is inspected three times, there are `3 x 5 = 15` opportunities for a miss.

Probability of a False Alarm (P_{fa}): The probability of a false alarm is the chance of rejecting a conforming part. This type of error is not as serious as a miss, since a conforming part is rejected. However, rejecting a conforming part causes rework and reinspection to be performed when it is not necessary. If the P_{fa} gets too large, large sums of money are wasted on rework and reinspection. The probability of a false alarm is computed by the following formula:

P_{fa} = number of false alarms/number of opportunities for a false alarm

The number of opportunities for a false alarm is a function of the number of conforming parts used in the study and the number of times each part is inspected. If six conforming parts are used and each part is inspected three times, there are `3 x 6 = 18` opportunities for a false alarm.

Bias (B): Bias is a measure of the tendency to classify an item as conforming or nonconforming. Bias is a function of P_{miss} and P_{fa}. Bias values are equal to or greater than zero and have the following interpretation:

B = 1 implies no bias.

B > 1 implies bias towards rejecting parts.

B < 1 implies bias towards accepting parts.

The value of bias is computed by:

$$B = P_{fa}/P_{miss}$$

Data Collection

The collection of samples for evaluating an inspection capability with attribute data is quite different from collecting samples for variable data.

The parts are not selected at random. Parts are selected by appropriate personnel and must be determined as conforming or nonconforming. The number of parts to be selected is shown in table 1. The parts are selected so there will be one-third conforming, one-third nonconforming and one-third marginal. Marginal parts are further divided so they are _ marginally conforming and _ marginally nonconforming. This results in the total sample being _ conforming and _ nonconforming.

Quantity of Appraisers	Quantity of Gages	Minimum Number of Parts	Minimum Number of Measurements per Part
1	0	24	5
1	1		
2	0	18	4
2 or More	1		
2	2 or More		
3 or More	0	12	3
2 or More	2 or More		

Table 1

Once the parts are selected, they are inspected once in random order by each inspector and the results are recorded on data sheets. Each inspector repeats an inspection and the results are recorded on separate data sheets to eliminate unintentional bias. This is repeated until the required number of inspections is completed. Inspectors should take a normal amount of time for each inspection.

Data Analysis

Analysis of the data is performed using the appropriate worksheets to compute P_{miss}, P_{fa}, E and B. The analysis procedure is illustrated by an example[1].

The example is concerned with a plating operation on a printer part. The visual inspection detects stains and deposits on the part after plating. Three persons are involved in the study: the plating operator, inspector and lead inspector. Seventeen parts are selected initially and after evaluation of the samples by the quality engineer, manufacturing engineer and inspection supervisor, 14 parts (8 conforming and 6 nonconforming) were actually used in the study. Each part was inspected three times. The data obtained is shown in table 2.

The column parked A/R contains the true condition of the part, where A is acceptable and R is reject.

The analysis consists mainly of counting and division. The details of the computations are shown in tables 3 and 4.

Attribute Example Data

Assembly	A/R	A			B			C		
		1	2	3	1	2	3	1	2	3
1	A	A	A	A	A	A	A	A	A	A
2	R	R	R	R	R	R	R	R	R	R
3	A	A	A	A	A	A	A	A	A	A
4	R	R	R	R	R	R	R	R	R	R
5	R	R	R	R	R	A	R	R	R	R
6	A	R	R	R	A	A	A	A	A	A
7	A	R	A	R	A	A	A	A	R	A
8	A	A	A	A	A	A	A	A	A	A
9	R	R	R	R	A	A	A	A	A	A
10	A	A	A	A	A	A	A	A	A	A
11	A	A	A	A	A	A	A	A	A	A
12	R	R	R	R	R	R	R	R	R	R
13	A	A	A	A	A	A	A	A	A	A
14	R	R	R	R	R	R	R	R	R	R

Table 2

Inspection Results

Appraiser	Number Good	Number Bad	Number Correct	Number False	Number Miss	Number Total

[1] *Total Quality Management Handbook*, Jack Hradesky, McGraw Hill, 1995

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	Correct	Correct		Alarms		
A	19	18	37	5	0	42
B	24	15	38	0	4	42
C	23	15	38	1	3	42

Table 3

Calculations

Appraiser	E	P_{fa}	P_{miss}
A	37/42=0.88	5/24=0.21	0/18=0
B	38/42=0.90	0/24=0	4/18=0.22
C	38/42=0.90	1/24=0.04	3/18=0.17

Table 4

The inspection capability study is evaluated using table 5 containing criteria for the parameters. For any marginally acceptable or unacceptable gages or appraisers, corrective action is required and when corrective action is completed, the inspection capability study must be redone.

Attribute Data Criteria

Parameter	Acceptable	Marginal	Unacceptable
E	> 0.90	0.80 to 0.90	< 0.80
P_{fa}	< 0.05	0.05 to 0.10	> 0.10
P_{miss}	< 0.02	0.02 to 0.05	> 0.05

Table 5