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UniODA *vs*. *Not* Chi-Square: Work Shift and Raw Material Production Quality

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The association between work shift and the quality of raw material produced—rated using a six-point graduated index—was incorrectly assessed using chi-square analysis.[1] Findings were compared with results of maximum-accuracy analysis via UniODA.

Data for this application are given in Table 1.

Table 1: Shift and Production Quality

	Work Shift			
Quality	A	B	C	*N*
1	11	17	6	34
2	23	29	21	73
3	8	10	8	26
4	5	17	24	46
5	18	7	15	40
6	18	15	9	42
N	83	95	83	261

Work shift and rated production quality were both treated as having been measured on categorical (unordered) scales, and their association was assessed by chi-square analysis[1]: χ^2 (df = 10, N = 261) = 26.3, $p < 0.01$. The null hypothesis of no association is rejected, and it is concluded there is an association between shift and production quality. It is natural to wonder, exactly what is the association between shift and quality? Disentangling this omnibus effect—specifying exactly what is the nature of the association—is a complex enterprise involving log-linear analysis.[2] An alternative approach is described[1]: “The χ^2 test … does not give any information as to the type of association. This can only be found by inspection of the original contingency table. To assist in this it is convenient to enter in each cell, alongside the observed frequency, the expected frequency. Doing this for the present example, we find that A shift were producing a relative excel of (scores of) 5 and 6, B shift of 1, and C shift of 4” (p. 47). Note that these 4 cells represent only 22.2% of the total of 18 cells in the design.

The assumption motivating applicability of the chi-square test is that data are categorical, not ordered. A graduated index of perceived quality is an ordered index, not categorical. Violation of this assumption of chi-square is widely seen in the literature.[3-6]

The nondirectional UniODA model discriminating work shift as a function of rated quality was identified using the UniODA[7,8] and MegaODA[9-11] software syntax:

```
OPEN quality.dat;
OUTPUT quality.out;
VARS shift quality;
CLASS shift;
```

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```
ATTRIBUTE quality;
MCARLO ITER 10000;
GO;
```

The UniODA model was: if quality $\leq$ 3 then predict shift B; if quality = 4 then predict shift C; and if quality $\geq$ 5 then predict shift A (note that UniODA criteria for shifts A and C agree with the original findings based on chi-square[1]). This association is statistically significant ($p < 0.0035$), however it reflects a relatively weak effect (*ESS* = 15.6). Model predictive accuracy is summarized in the confusion table given in Table 2 (PV = predictive value).

Table 2: Confusion Table for UniODA Model

Actual Shift	Predicted Shift A	B	C	Sensitivity
A	36	42	5	43.4
B	22	56	17	59.0
C	24	35	24	28.9
PV	43.9	42.1	52.2	

If the quality index was categorical then the maximum-accuracy UniODA model would be identified by appending the following syntax to the program given above:

```
CATEGORICAL quality;
```

In this application the UniODA model is identical, as is classification performance. However exact $p < 0.024$.

References

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Author Notes

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