BIO 682
Nonparametric Statistics
Spring 2010

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http://www4.nau.edu/shustercourses/BIO682/index.htm

Lecture 7

k-Sample Tests

1. Tests in which population is sampled *multiple times*.
2. Good example: Cochran's Q test.

a. A test for nominal scale data that tests for *changes over time*

b. Similar to McNemar’s test, except that duration is not limited to two samples.

Cochran’s Q Test

1. Faculty responses to New Plan at various times in over the last few months.

a. Possible to examine the effect of time on subjects.

b. Useful to have a control in most cases (not always possible).

Cochran's Q Test: Method

1. examine matrix with:

a. a = # of columns (sampling events)

b. b = # of rows (subjects)

c. Y = score for each individual at time a_i (0 or 1)

Cochran's Q Test: Method

b_i	a_1	a_2	a_3	Σ	
1	0	1	0	1	1
2	0	0	0	0	0
3	1	1	0	2	4
4	1	0	0	1	1
5	1	1	0	2	4
6	1	0	0	1	1
7	0	0	0	0	0
8	1	1	1	3	9
9	1	1	0	2	4
10	1	0	0	1	1
Σ	7	5	1	13	25
	49	25	1	75	

Calculate:

1. $\sum^{ab}\sum Y_i = 13 = A$
2. $\sum^{b}(\sum^{a} Y_i)^2 = 25 = B$
3. $\sum^{a}(\sum^{b} Y_i)^2 = 75 = C$

Cochran's Q Test: Method

$$Q = \frac{(a-1)\,[a\,(C) - (A)^2]}{a\,(A) - B}$$

$$= \frac{(3-1)\,[3(75) - 169]}{3(13) - 25}$$

$$= 8.$$

with df = $(a-1) = 2$, ($X^2 = 5.99$), $P < .05$

People change.

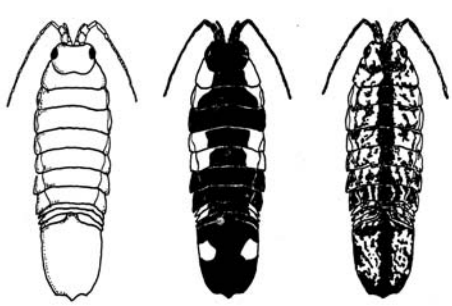
RxC Tests

1. Like a contingency table but with *more than* 2 rows or columns.
2. The classic method: RxC X^2 test.
   a. Method:
      1. Marginal values calculated as with 2x2 test.
      2. Add up all X^2 values for cells.
3. Has same problems with being cumbersome as 2x2 X^2 test.

RxC *G*-tests

1. Has same advantages as before, same rules:
   a. for $a > 5$ and $f_{i\text{-hat}} > 3$; *G* is *better* than X^2
   b. Use an exact test when:
      a. $a > 5$ and $f_{i\text{-hat}} < 3$
      b. $a < 5$ and $f_{i\text{-hat}} < 5$
2. Commonly used test to examine independence of multiple classes.

Example: *Idotea baltica*



uniformis *albufusca* *maculata*

Example: *Idotea baltica*

	M	J	J	A	
uniformis	254	185	93	55	587
albafusca	185	144	123	190	642
maculata	66	98	200	305	669
	505	427	416	550	1898
obs. *f* mac.	.13	.23	.48	.55	avg = .35

Example: *Idotea baltica*

1. RxC test allows you to test the hypothesis that the observed frequencies *don't change.*

2. Same method as 2x2:
[(Σ*G*-cells)-(Σ*G*-rows)-(Σ*G*-columns)+(*G*-N)]

a. with df = $(r-1)(c-1) = 6$.

3. Williams' correction is used for sample sizes <200.

a. Is a lot more complicated than before (see p. 745).

Williams' Correction: RxC

$$q = \frac{\left(n\sum^{b} 1/\sum^{a} f - 1\right)\left(n\sum^{b} 1/\sum^{a} f - 1\right)}{6n(a-1)(b-1)}$$

But the shorter version provides a lower boundary (a conservative substitute),

$$q = 1 + [(a+1)(b+1)]/6n$$

RxC and Heterogeneity Tests

1. They are functionally analogous.

2. They both test whether the samples differ in their *observed frequencies*.

3. The difference is that heterogeneity tests are based on an *extrinsic hypothesis*.

4. RxC tests are based on marginal totals, therefore the hypothesis is *intrinsic* to data.

RxC: What is the Question?

1. Do the relative frequencies *change*?

2. A significant *G*-value tells you that differences ***DO*** exist among categories.

a. But, doesn't say much about ***where*** they are.

3. To answer this question, it is possible to collapse RxC into a series of 2x2 tests.

Collapsing Cells

1. It is necessary to pool adjacent rows and/or columns to reduce the number of comparisons.

	M	J	J	A	
uniformis	254	185	93	55	587
albafusca	185	144	123	190	642
maculata	66	98	200	305	669
	505	427	416	550	1898
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Measures of Association

1. The converse of tests of independence are tests of association.
   a. If H_o is rejected, inference can be that factors are associated.
   b. Examples:
      1. Nonparametric correlations (Spearman's r; Kendall's tau).
      2. Friedman's test
2. Three-way, multiple way contingency tables.

k-Way Tables

1. Multi-way contingency tables
   a. Like ANOVA; they test the effect of multiple factors on observed values
   b. However,
      1. ANOVA is concerned with *main effects*
         a. If interactions are found, it is often difficult to identify their source.
      2. Multi-way tables are specifically concerned with identifying source of interactions.

Ordinal Scale Tests

1. One sample cases- Runs test
   a. There are many cases in which the order in which events occur is of interest.
   b. Concern with independence, randomness.
   c. Individuals choosing different sides of an experimental chamber.
   d. Sequence in which different sexes defend territory.
2. Whenever it is possible to record the order in which events occur.

Coin Flips

1. Possible extremes in 20 tosses:
   - *a.* *All* heads or *all* tails.
   - b. 10 heads followed by 10 tails
   - c. T H T H T H T H T H T H T H T H T H T H
2. More likely, there is some intermediate pattern:

   HH TTT H TTT HHH T H TTT H
3. In each case it is possible to count the number of "runs" that occur (r).

Counting Runs

1. The first two cases have *fewer* runs than expected by chance (r =1 and 2)
2. The third has *more* runs than expected by chance (r = 20)
3. the forth has r = 9.
4. The number of runs (r) will depend on:
   - a. *m* - # of events of one type
   - b. *n* - # of events of the other type
   - c. Since these variables count all events,

     N= r = *n*+*m*.

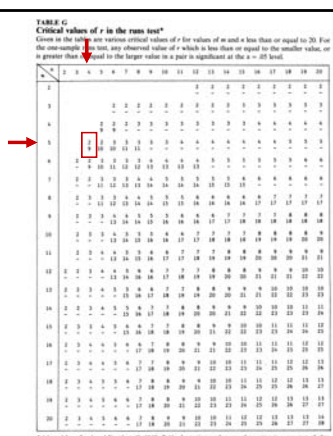
TABLE G
Critical values of *r* in the runs test*
Given in the tables are various critical values of *r* for values of *m* and *n* less than or equal to 20. For the one-sample runs test, any observed value of *r* which is less than or equal to the smaller value, or is greater than or equal to the larger value in a pair is significant at the α = .05 level.

Small Samples

1. Where m and $n < 20$

a. Use Table G (S&C)

b. Provides the values for m and n

c. Also, boundaries of values for r that could occur 95% of the time.

1. Thus, provides a *2-tailed test.*

2. If a 1-tailed test: Ho is rejected is at $\alpha = .025$

Large Samples

1. When m and $n > 20$:

1. The value of z is based on a normal distribution.

$$z = \frac{r + h - \mu_r}{\sigma_r}$$

where r = # of runs

Where,

a. $\mu_r = (2mn/N) + 1$

b. $\sigma_r = \sqrt{\{[2mn(2mn - N)] / [N^2(n-1)]\}}$

c. h = .5 if r < [(2mn/N)+1] and -.5 if r > [(2mn/N)+1].

Two Sample Cases

1. The Sign Test

a. One of the simplest tests using ordinal data.

b. Is used like a binomial test to determine the *order* of two samples.

Example: Sign Test

1. The number of warning cries delivered against intruders by male and female pairs of trogons.