# Specific Comparisons (Correlated Observations)

**Prerequisites**
Hypothesis Testing, Testing a Single Mean, t Distribution, Specific Comparisons, Difference Between Means, Related Pairs

In the Weapons and Aggression case study, subjects were asked to read words presented on a computer screen as quickly as they could. Some of the words were aggressive words such as injure or shatter. Others were control words such as relocate or consider. These two types of words were preceded by words that were either the names of weapons such as shot gun and grenade or non-weapon words such as rabbit or fish. For each subject, the mean reading time across words was computed for these four conditions. The four conditions are labeled as shown in Table 1. Table 2 shows the data for five subjects.

Table 1. Description of Conditions.

| Variable | Description |
|---|---|
| aw | The time in milliseconds (msec) to name aggressive word following a weapon word prime. |
| an | The time in milliseconds (msec) to name aggressive word following a non-weapon word prime. |
| cw | The time in milliseconds (msec) to name a control word following a weapon word prime. |
| cn | The time in milliseconds (msec) to name a control word following a non-weapon word prime. |

Table 2. Data from Five Subjects

| Subject | aw | an | cw | cn |
|---|---|---|---|---|
| 1 | 447 | 440 | 432 | 452 |
| 2 | 427 | 437 | 469 | 451 |
| 3 | 417 | 418 | 445 | 434 |
| 4 | 348 | 371 | 353 | 344 |
| 5 | 471 | 443 | 462 | 463 |

One question was whether reading times would be shorter when the preceding word was a weapon word (aw and cw conditions) than when it was a non-weapon word (an and cn conditions). In other words, is

$$L_1 = (an + cn) - (aw + cw)$$

greater than 0? This is tested for significance by computing L1 for each subject and then testing whether the mean value of L1 is significantly different from 0. Table 3 shows L1 for the first five subjects. L1 for Subject 1 was computed by

$$L_1 = (440 + 452) - (447 + 432) = 892 - 885 = 13$$

Table 3. L1 for Five Subjects

| Subject | aw | an | cw | cn | $L_1$ |
|---|---|---|---|---|---|
| 1 | 447 | 440 | 432 | 452 | 13 |
| 2 | 427 | 437 | 469 | 451 | -8 |
| 3 | 417 | 418 | 445 | 434 | -10 |
| 4 | 348 | 371 | 353 | 344 | 14 |
| 5 | 471 | 443 | 462 | 463 | -27 |

Once $L_1$ is computed for each subject, the significance test described in the section "Testing a Single Mean" can be used. First we compute the mean and the standard error of the mean for $L_1$. There were 32 subjects in the experiment. Computing $L_1$ for the 32 subjects, we find that the mean and standard error of the mean are 5.875 and 4.2646 respectively. We then compute

$$t = \frac{M - \mu}{s_M}$$

where M is the sample mean, μ is the hypothesized value of the population mean (0 in this case), and $s_M$ is the estimated standard error of the mean. The calculations show that t = 1.378. Since there were 32 subjects, the degrees of freedom is 32 - 1 = 31. The t distribution calculator shows that the two-tailed probability is 0.1782.

A more interesting question is whether the priming effect (the difference between words preceded with a non-weapon word and words preceded by a weapon word) is different for aggressive words than it is for non-aggressive words. That is, do weapon words prime aggressive words more than they prime non-aggressive words? The priming of aggressive words is (an - aw). The priming of non-aggressive words is (cn - cw). The comparison is the difference:

$$L_2 = (an - aw) - (cn - cw)$$

Table 4 shows $L_2$ for five of the 32 subjects.

Table 4. L2 for Five Subjects

| Subject | aw | an | cw | cn | $L_2$ |
|---|---|---|---|---|---|
| 1 | 447 | 440 | 432 | 452 | -27 |
| 2 | 427 | 437 | 469 | 451 | 28 |
| 3 | 417 | 418 | 445 | 434 | 12 |
| 4 | 348 | 371 | 353 | 344 | 32 |
| 5 | 471 | 443 | 462 | 463 | -29 |

The mean and standard error of the mean for all 32 subjects are 8.4375 and 3.9128 respectively. Therefore, $t = 2.156$ and $p = 0.039$.

**Multiple Comparisons**

Issues associated with doing multiple comparisons are the same for related observations as they are for multiple comparisons among independent groups.

**Orthogonal Comparisons**

The most straightforward way to assess the degree of dependence between two comparisons is to *correlate* them directly. For the weapons and aggression data, the comparisons $L_1$ and $L_2$ are correlated 0.24. Of course, this is a sample correlation and only estimates what the correlation would be if $L_1$ and $L_2$ were correlated in the whole population. Although mathematically possible, orthogonal comparisons with correlated observations are very rare.