

THE VARIANCE FOR MULTIPLE-CALLING ESP DATA

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IN CONDUCTING TESTS of ESP, it is sometimes not convenient to provide a separate target for each call. For example, a classroom test may be conducted with much greater economy of effort if all the students are permitted to call the same pack of ESP symbols instead of having a separate order of targets for each one. Greville (*Annals of Mathematical Statistics*, 1944, Vol. XV, No. 4) has worked out the statistical method for obtaining the exact theoretical variance for such a case of multiple calling. His publication is not readily available to research workers, and the generalized statement of the problem is in symbolic mathematical terms which relatively few investigators are able to apply to a specific set of data without the help of a statistician. The purpose of this note is not to explain the underlying theory of this method but to illustrate its use as applied to multiple calling of ESP targets and to provide simple directions for making the computations.

Two target situations which are commonly used may be considered. (1) The targets are chosen at random, so that the probability of any one of the five symbols being the target is independent of the other targets. (2) The targets are chosen by taking the order of symbols in a randomly selected permutation of a closed ESP pack, i.e., 25 cards consisting of 5 of each of the 5 symbols.

For both (1) and (2), chance expectation of correct calls is 20% of the total number of calls. This is true for both single and multiple calling, so multiple calling presents no difficulty insofar as getting the deviation from mean chance expectation is concerned.

To illustrate the calculations of the variance in a hypothetical set of data, let us assume that 10 subjects called the same set of 25 ESP targets. For targets of either type, (1) or (2), it is necessary that the distribution of selected symbols on each set of calls for a single target be obtained. These may conveniently be arranged as shown in Table 1.

Table 1

ASSUMED DATA FROM TEN SUBJECTS CALLING ONE SET OF 25 TARGETS

Distribution of Calls

Target Number	Waves	Star	Circle	Square	Cross	Total Calls for Each Target
1.....	2	1	3	1	3	10
2.....	1	2	4	0	3	10
3.....	3	2	3	1	1	10
4.....	1	1	3	2	3	10
5.....	1	3	2	2	2	10
6.....	1	1	5	2	1	10
7.....	3	2	3	2	0	10
8.....	2	1	2	2	3	10
9.....	2	3	3	1	1	10
10.....	1	1	2	3	3	10
11.....	3	0	4	2	1	10
12.....	2	2	3	1	2	10
13.....	0	3	2	3	2	10
14.....	1	2	5	0	2	10
15.....	2	3	2	2	1	10
16.....	1	3	4	1	1	10
17.....	2	2	3	2	1	10
18.....	2	2	2	2	2	10
19.....	0	2	3	3	2	10
20.....	0	3	4	2	1	10
21.....	1	3	5	1	0	10
22.....	2	2	3	1	2	10
23.....	3	1	2	3	1	10
24.....	1	3	3	3	0	10
25.....	2	3	4	0	1	10
Total calls for each symbol. . .	39	51	79	42	39	250 = Total calls

(1) Variance for random targets:

If the ten subjects of the hypothetical group were calling randomly selected targets, the results of each trial would be statistically independent of the others, and the variance of the number of correct calls on each target is given by the expression:

$$(\text{Probability of each target}) \times (\text{Sum of squares of calls for each symbol}) - (\text{Square of expected number of correct calls}).$$

For the first target in Table I, this is:

$$(1/5) \times (2^2 + 1^2 + 3^2 + 1^2 + 3^2) - (2^2) = 4/5.$$

The variance for each of the other targets is computed similarly, and the total variance for the entire set of 250 calls is obtained by summing the variances for the 25 targets. If the calls of Table 1 were made against random targets, this total variance is found to be 30.4.

The standard deviation is the square root of this value, i.e., 5.51. This may be compared with the standard deviation of $\sqrt{40} = 6.32$ for the situation in which each of 10 subjects makes 25 calls for a different randomly selected order of 25 targets.

(2) Variance for the balanced or closed ESP pack:

If the targets were provided by a randomly selected permutation of the standard ESP pack, the variance for data involving multiple calling must be obtained for the entire set of 25 targets as the unit, and the computations are more involved than for data based upon random targets. The quantities required in the calculations are:

- (a) The number of ESP symbols = 5
- (b) The number of targets = 25
- (c) The sum of squares of the call frequencies
in each of the 250 calls of Table 1 =
 $2^2 + 1^2 + 3^2 + 1^2 + 3^2 + 1^2 + \dots + 4^2 + 0^2 + 1^2 = 652$
- (d) The sum of the squares of the total
calls of each symbol =
 $39^2 + 51^2 + 79^2 + 42^2 + 39^2 = 13,648$
- (e) The sum of the squares of the total
calls for each target =
 $(25)(10^2) = 2,500$
- (f) The square of the total number of calls =
 $250^2 = 62,500$

Then, for the closed pack:

$$\begin{aligned}
 \text{Variance} &= \frac{(a)(be - d) - be + f}{(a^2)(b - 1)} \\
 &= \frac{(5)(25 \times 652 - 13,648) - (25)(2,500) + 62,500}{(25)(24)} \\
 &= \frac{13,260}{600} \\
 &= 22.1 \\
 \text{S.D.} &= \sqrt{22.1} = 4.70
 \end{aligned}$$

This may be compared with the variance of 41.67 (S.D. = 6.46) which is the theoretical value for the total score from 10 runs based upon a different set of 25 calls for each of 10 ESP closed packs.

The above method for finding the variance of the balanced pack may be applied to multiple calling data with runs of any length in which all targets are presented the same number of times. It is not necessary for (b) to be the square of (a), as happens to be the case in the standard ESP pack of 25 cards.

The Greville method applied to the assumed set of calls shown in Table 1 gives a lower variance for both (1) and (2) than the method appropriate for single calls. In actual practice, it is generally found to give a higher variance. In all events, the only safe procedure is to use the correct method.

The variance for both (1) and (2) may be obtained regardless of whether the same number of calls are made on each trial. It will be seen that the computation for the closed pack is simplified somewhat if every subject makes a call on every target, as then $(be) = f$ and these two quantities cancel out in the formula given above. For (1), it is not necessary to deal with the data in standard runs, but the series may be of any desired length. For (2), the variance must be computed for each set of calls made upon a random permutation of the closed pack, and the separate variances of the sets of calls for each pack of 25 targets are added to get the total variance for the data as a whole.

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