Are You Gifted?

Objective of the game: "Test" for telepathy by pairing off students and giving each student a deck of ESP cards. Record the number of correct responses.

Objective of the lesson: Test of hypotheses: one sample and paired difference
This activity also refers to binomial distribution and chi-square.

Questions:

1. If there is no latent ESP ability, how many cards would one expect to be guessed correctly?
2. Does the number of correct responses differ significantly from what is expected?
3. Does practice improve the power of ESP?
4. Can any conclusion be made about an individual student?

Procedure:

1. Each pair of students needs a copy of a random number table and a set of five different cards and will determine who will be the "receiver" and who will be the "sender".
2. Students sit across from each other, back to front, so that the "receiver" cannot see the results as they are being recorded.
3. The "sender" lays out the 5 cards on the desk in any order and then uses the random number table to determine which image to send. Let 1 correspond to the first card, 2 to the second, etc. Ignore all other digits. Thinking hard, the image is sent to the partner.
4. After a few seconds, the "receiver" states the symbol.
5. The "sender" records whether the guess was correct and gets the next digit from the random number table to determine the next image to send.
6. Repeat 30 times. Let the receiver know the final score.
7. Switch jobs. Perhaps the "sender" is a better "receiver".
8. Repeat the entire procedure again. Perhaps the second time will show an improvement.
9. Record all data on the student data sheet.

Question #1: If there is no latent ESP ability, how many cards would one expect to be guessed correctly?

This is an example of a binomial distribution with a probability of 0.2 (1/5). Then one would expect to get, on average, (.2)(30) = 6 correct answers per student. Multiply by the number of students who were receivers to get total number of correct answers for the class.

This situation satisfies all of the conditions of the binomial distribution because it is:
B – binomial: the "receiver" answers correctly or incorrectly
I – independent: the answer for one card does not affect the answer for the next card
N – number fixed: there are a fixed number of trials, in this case 30 each time
S – same probability: because a random number table is being used, the probability does not change from trial to trial under the hypothesis of no ESP.

Notes:

1) A random number table must be used to allow any possible combination of cards, including "streaks".

2) If a deck of 30 cards were to be created and the sender used them one at a time, the situation would no longer be binomial since the probability would change after each card.
3) The receiver should not know the score until after all 30 trials have been completed. This will avoid creating "receiver anxiety" which could confound the results.

Student data tables: Each square represents an individual trial. Mark it with a √ if the answer is correct and an X if the answer is wrong. Each student is tested twice.

Total number correct: ________

Total number correct: ________

Class data table:

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Test #1															
Test #2															

Student	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Test #1															
Test #2															

Total number correct for the class: ________
Total number of responses for the class: ________
Total proportion of correct responses for the class: _______

Question #2: Does the proportion of correct responses differ significantly from what is expected?

This requires a test of hypotheses to determine if the class value is due to mere chance. Because we are interested in showing that the quality of ESP exists, it is a one-tailed test.

Example: Let n = 1200 trials with 250 correct responses.

Hypotheses: H_0: p = 0.2
H_a: p > 0.2

Assumptions: sample size is large enough: np = (1200)(0.2) = 240 >10
and nq = (1200)(0.8) = 960 >10

Test to be used: one-proportion z-test. This data is a count of responses. It is not an average value, and thus a test of means is not appropriate.

Test statistic: z = .722 with a p-value of 0.235. The critical value that begins the rejection region for an α value of 0.05 is 1.645

Conclusion: There is not enough evidence to reject the null hypothesis that the proportion of guesses differs significantly from 0.2. There is not enough evidence to conclude that this class exhibits a facility in ESP.

Question #3: Does practice improve the power of ESP?

There are two ways to interpret this question: (1) Does the class improve as a whole? and (2) Was there improvement individually? Two different tests are required for this. (1) can be answered by comparing the two class percentages. The second requires a paired difference test between individual student scores. Again this is a one-tailed test since one is looking for improvement.

Example: Consider the class as a whole. Let $n_1 = n_2 = 1200$ trials with $x_1 = 250$ correct responses and $x_2 = 255$ responses.

Hypotheses: $H_0: p_1 = p_2$
$H_a: p_1 < p_2$

Assumptions: sample size is large enough:

$n_1\hat{p}_1 = (1200)(.2083) = 250 > 10$ $\quad n_2\hat{p}_2 = (1200)(0.2125) = 255 > 10$

and $n_1\hat{q}_1 = (1200)(.7917) = 950 > 10$ $\quad n_2\hat{q}_2 = (1200)(0.7875) = 945 > 10$

Test to be used: two-proportion z-test. This data is a count of responses. It is not an average value, and thus a test of means is not appropriate.

Test statistic: z = -0.254 with a p-value of 0.401. The critical value that begins the rejection region for an α value of 0.05 is 1.645

Conclusion: There is not enough evidence to reject the null hypothesis that the proportion of guesses for the second experiment differs significantly from the result of the first experiment. There is not enough evidence to conclude that practice improved the class's facility in ESP.

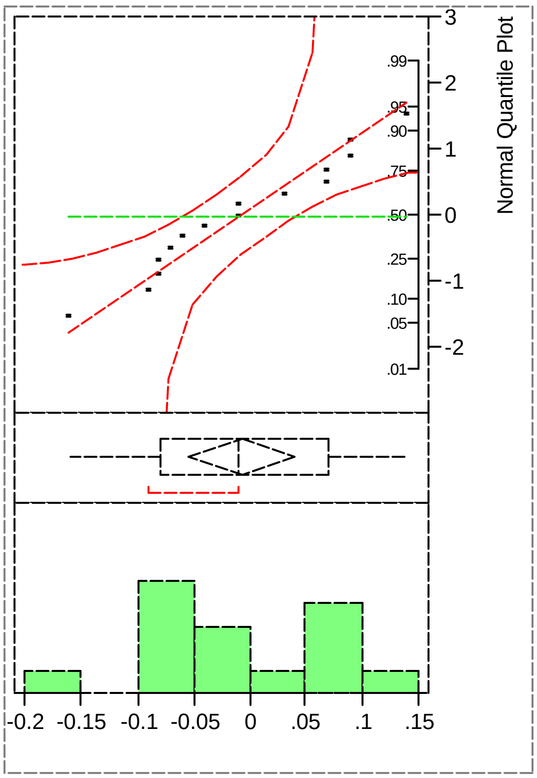
Example: Consider the change in successful responses by individual students. Now there will be 30 pairs of data and the test will be run on their differences. The underlying assumption is that the population of differences is approximately normal. The test will be a one-sample t-test; we do not know the population standard deviation. Data is the number of correct responses by each student for a class of size 15.

Student	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Test #1	1	5	3	1	5	1	2	0	3	4	6	7	2	5	8
Test #2	4	5	5	2	1	3	5	4	2	2	5	3	1	5	2

Hypotheses: $H_0: \mu = 0$

$H_a: \mu < 0$

Assumptions: The underlying population of differences is approximately normal. It is reasonable to assume this, but since the original data is available, it is possible to check this assumption by graphing the differences using a boxplot, histogram, or normal quantile plot. Note that the data all falls within the confidence bands and are fairly linear.



Test to be used: one sample t-test.

Test statistic: t = .357 with 14 degrees of freedom and a p-value of 0..637. The critical value that begins the rejection region for an α value of 0.05 is –1.761

Conclusion: There is not enough evidence to reject the null hypothesis that the individual differences of proportions of guesses for the second experiment differs significantly from the result of the first experiment. There is not enough evidence to conclude that practice improved an individual's facility in ESP.

Question #4: Can any conclusion be made about an individual student?

This is not really a trick question, but since each individual student only tried the experiment twice, it is not possible to answer the questions honestly. If a student is interested, there are web sites that allow one to test their psychic ability.

Bonus: Are sheep different from goats?

There has been research that suggests that people who believe in psychic powers (sheep) are more likely to possess this ability than those who are skeptical (goats). Students need to identify themselves as sheep or goats, and then accumulate the data to complete the class data chart.

Example:

	Number correct	Number wrong
Sheep	150	436
Goats	114	500

Hypotheses: H_0: The ability to guess correctly is not related to the individual's belief.
H_a: The ability to guess correctly is related to the individual's belief

Assumptions: Expected count for each individual cell is at least 5.

Test to be used: chi-square test of association

Test statistic: $X^2 = 8.637$ with 1 degree of freedom and a p-value of 0.0033. The critical value that begins the rejection region for an α value of 0.05 is 3.84

Conclusion: There is sufficient evidence to reject the null hypothesis that the individual status is not related to of the number of correct answers. That is, there is reason to believe that "sheep" and "goats" perform differently on tests of psi ability.

Note: The following web site will allow your students to pursue this topic in more detail.

On-line ESP tests: www.noetics.org
Go about ¾ of the way down the page and click on *Test your psi ability!* – online psi experiments by Dean Radin, Senior Scientist at IONS.

Or, go directly to: http://csl.lfr.org/bi/gotpsi.htm