

Using Simulations to Approximate p -values in AP Statistics

Example #1: A one sample test for a proportion:

Recently, a company had to downsize and fire 10 employees. Of these 10 employees, 5 were women (50%). However, only 10 of the company's 30 employees were women (33%). This discrepancy has led the women who were fired to file a sexual discrimination lawsuit. Do they have a legitimate claim?

Example #2: A two sample test for a difference in means:

In a study on the “The Antihypertensive Effects of Fish Oil,” researchers randomly divided 14 male volunteers with high blood pressure to one of two treatments. The first treatment was a 4-week diet that included fish oil and the second was a 4-week diet that included regular oil. The response variable was the reduction in diastolic blood pressure (mm of mercury). The results of this study are shown below. [Source: *New England Journal of Medicine* 320 (1989): 1037-1043; cited in The Statistical Sleuth, by Ramsey and Schafer, page 23.] Can we conclude that fish oil is better than regular oil for reducing diastolic blood pressure?

Fish Oil:	8	12	10	14	2	0	0	$\bar{x}_f = 6.57$
Regular Oil:	-6	0	1	2	-3	-4	2	$\bar{x}_r = -1.14$

Note: It is possible that this experiment could have been carried out using a matched pairs design. This could be accomplished by pairing the two subjects with the highest initial blood pressure and splitting them to the two treatments at random. This process would be repeated for the next two highest, etc.

To estimate the p-value using simulation, simply re-randomize the responses for the members of the pair, recalculate the differences, and look at the distribution of differences.

Example #3: A one sample test for the slope of a least squares regression line:

When people have colds, common wisdom says to avoid dairy products since they produce extra mucus. However, this claim was challenged by researchers in Australia in 1990. They infected volunteers with a cold virus and assigned them at random to drink different amounts of milk. Meanwhile, all used tissues were weighed to measure nasal mucus secretions (based on an article in Nutrition Action 12-04). Based on the data below, can we conclude that there is a positive association between milk consumption and mucus secretion?

Glasses of Milk	Ounces of Mucus
0	0.7
0	0.3
0	0.6
1	0.5
1	0.8
1	1.3
2	0.2
2	0.9
2	1.1
3	0.5
3	0.6
3	1.2
4	0.5
4	0.8
4	1.3

Example #4: A two sample test for a difference in proportions (based on #5 from the 2007 AP exam)

Researchers want to determine whether drivers are significantly more distracted while driving while using a cell phone than when talking to a passenger in the car. In a study involving 48 people, 24 people were randomly assigned to drive in a driving simulator while using a cell phone. The remaining 24 were assigned to drive in the driving simulator while talking to a passenger in the simulator. Part of the driving simulation for both groups involved asking drivers to exit the freeway at a particular exit. In the study, 7 of the 24 cell phone users missed the exit, while 2 of the 24 talking to a passenger missed the exit. Based on this data, what can we conclude?

Note: This same approach can be used to estimate p-values for chi-square tests of independence and homogeneity of proportions. However, instead of calculating the difference in proportions, you would calculate the chi-square statistic for the newly randomized distribution and look at the distribution to see if the original chi-square value is unusual or not.

For a simulation approach to the chi-square goodness of fit test, see the great paper by Dan Teague: <http://courses.ncssm.edu/math/Talks/PDFS/Chi-Square%20Analyses.pdf>