Parametric vs. Non-parametric Tests

We looked at data distributions to assess center, shape and spread and described how the validity of many statistical procedures relies on an assumption of approximate normality. But what do we do if our data are not normal? Nonparametric procedures are one possible solution to handle non-normal data.

We can define nonparametric statistical procedures as a class of statistical procedures that do not rely on assumptions about the shape or form of the probability distribution from which the data were drawn. . When the sample size is small and the distribution of the outcome is not known and cannot be assumed to be approximately normally distributed, then nonparametric tests are appropriate.

There are two types of test data and consequently different types of analysis. As the table below shows, parametric data has an underlying normal distribution which allows for more conclusions to be drawn as the shape can be mathematically described. Anything else is non-parametric.

	Parametric	**Non-parametric**
Assumed distribution	Normal	Any
Assumed variance	Homogeneous	Any
Typical data	Ratio or Interval	Ordinal or Nominal
Data set relationships	Independent	Any
Usual central measure	Mean	Median
Benefits	Can draw more conclusions	Simplicity; Less affected by outliers
Tests		
Choosing	Choosing parametric test	Choosing a non-parametric test
Correlation test	Pearson	Spearman
Independent measures, 2 groups	Independent-measures t-test	Mann-Whitney test
Independent measures, >2 groups	One-way, independent-measures ANOVA	Kruskal-Wallis test
Repeated measures, 2 conditions	Matched-pair t-test	Wilcoxon test
Repeated measures, >2 conditions	One-way, repeated measures ANOVA	Friedman's test

Reasons to Use Parametric Tests

Reason 1: Parametric tests can perform well with skewed and non-normal distributions

Prametric tests can perform well with continuous data that are non-normal if you satisfy the sample size guidelines in the table below.

Parametric analyses	**Sample size guidelines for non-normal data**
1-sample t test	Greater than 20
2-sample t test	Each group should be greater than 15
One-Way ANOVA	• If you have 2-9 groups, each group should be greater than 15. • If you have 10-12 groups, each group should be greater than 20.

Reason 2: Parametric tests can perform well when the spread of each group is different

While nonparametric tests don't assume that your data follow a normal distribution, they do have other assumptions that can be hard to meet. For nonparametric tests that compare groups, a common assumption is that the data for all groups must have the same spread (dispersion). If your groups have a different spread, the nonparametric tests might not provide valid results.

Reason 3: Statistical power

Parametric tests usually have more statistical power than nonparametric tests. Thus, you are more likely to detect a significant effect when one truly exists.

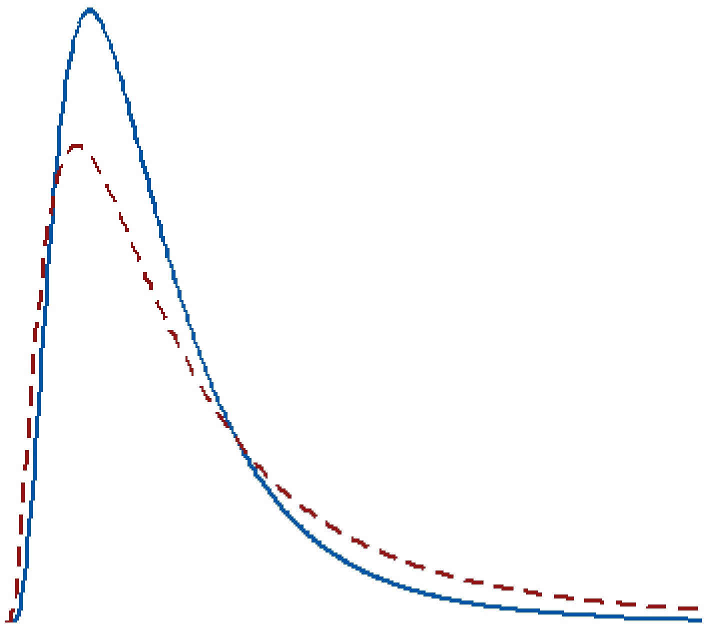
Nonparametric Tests

Nonparametric tests are also called distribution-free tests because they don’t assume that your data follow a specific distribution.

Parametric tests (means)	Nonparametric tests (medians)
1-sample t test	1-sample Sign, 1-sample Wilcoxon
2-sample t test	Mann-Whitney test
One-Way ANOVA	Kruskal-Wallis, Mood’s median test
Factorial DOE with one factor and one blocking variable	Friedman test

Reasons to Use Nonparametric Tests

Reason 1: Your area of study is better represented by the median



The fact that you *can* perform a parametric test with nonnormal data doesn’t imply that the mean is the best measure of the central tendency for your data. For example, the center of a skewed distribution, like income, can be better measured by the median where 50% are above the median and 50% are below. If you add a few billionaires to a sample, the mathematical mean increases greatly even though the income for the typical person doesn't change.

When your distribution is skewed enough, the mean is strongly affected by changes far out in the distribution's tail whereas the median continues to more closely reflect the center of the distribution. For these two distributions, a random sample of 100 from each distribution produces means that are significantly different, but medians that are not significantly different.

Reason 2: You have a very small sample size

If you don't meet the sample size guidelines for the parametric tests and you are not confident that you have normally distributed data, you should use a nonparametric test. When you have a really small sample, you might not even be able to determine the distribution of your data because the distribution tests will lack sufficient power to provide meaningful results.

Reason 3: You have ordinal data, ranked data, or outliers that you can't remove

Typical parametric tests can only ass1[ess continuous data and the results can be significantly affected by outliers. Conversely, some nonparametric tests can handle ordinal data, ranked data, and not be seriously affected by outliers. Be sure to check the assumptions for the nonparametric test because each one has its own data requirements.

Closing Thoughts

It's commonly thought that the need to choose between a parametric and nonparametric test occurs when your data fail to meet an assumption of the parametric test. This can be the case when you have both a small sample size and non-normal data.

The decision often depends on whether the mean or median more accurately represents the center of your data's distribution.

- If the mean accurately represents the center of your distribution and your sample size is large enough, consider a parametric test because they are more powerful.
- If the median better represents the center of your distribution, consider the nonparametric test even when you have a large sample.

Hypothesis Testing with Nonparametric Tests

In nonparametric tests, the hypotheses are not about population parameters (e.g., μ=50 or $\mu_1=\mu_2$). Instead, the null hypothesis is more general. For example, when comparing two independent groups in terms of a continuous outcome, the null hypothesis in a parametric test is H_0: $\mu_1 = \mu_2$. In a nonparametric test the null hypothesis is that the two populations are equal, often this is interpreted as the two populations are equal in terms of their central tendency.