Conditions and Test Statistics for Statistical Tests

Inference About: (Number of Samples)	**Name of Test**	**Test Statistic**	**Conditions**	**Nonparametric Option**
Proportion (1 sample)	**Z-Test**	$Z = \frac{\hat{p}-p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}}$	• Random sample • n is large (at least 10 successes and 10 failures)	None
Proportion (2 sample)	**2-Sample Z test**	$Z = \frac{(\hat{p}_1-\hat{p}_2)}{\sqrt{\frac{\hat{p}(1-\hat{p})}{n_1}+\frac{\hat{p}(1-\hat{p})}{n_2}}}$ Note: $\hat{p} = \frac{X_1+X_2}{n_1+n_2}$	• Two independent random samples • n_1 and n_2 large (at least 10 successes and 10 failures)	None
Proportion (1 sample)	**Binomial Test**	$\Pr(\mathrm{X}) = \binom{n}{X} p^X (1-p)^{n-X}$	• Every outcome is either a success or failure • Number of trials is fixed • Separate trials are independent • Probability of success is the same for each trial	None
Test to determine if distribution of a nominal variable matches predicted distribution (1 sample)	χ^2 **Goodness of Fit Test**	$\chi^2 = \sum \frac{(observed-expected)^2}{expected}$ $df =$ num. of cat. -1	• Random sample • All expected counts at least 5	None

Inference About: (Number of Samples)	**Name of Test**	**Test Statistic**	**Conditions**	**Nonparametric Option**
Relationship Between 2 Categorical Variables	χ^2 **Contingency Test**	$\chi^2 = \sum \frac{(observed - expected)^2}{expected}$ $df = (r-1)(c-1)$	• Random sample(s) • No more than 20% of cells have counts less than 5, and all are at least 1	Fisher's Exact Test
Relationship Between 2 Categorical Variables: Special Case $2X2$ table	**Fisher's Exact Test**	$P = \sum \frac{(R_1!R_2!)(C_1!C{-}2!)}{N!a_{1,1}a_{1,2}a_{2,1}a_{2,2}}$ N= sum of all entries. The sum is taken over all tables with the same row and column total with P values at least as extreme as the first	• Random sample(s) • Used when expected count levels are not met for the χ^2 test	
Mean (1 sample, unpaired)	**One-sample t-Test**	$t = \frac{(\bar{x} - \mu_0)}{\frac{s}{\sqrt{n}}}$ $df = n - 1$	• Random sample • Population has normal distribution OR sample size is large ($n > 30$)	Sign Test
Median (1 sample) **Nonparametric Test**	**Sign Test**	S = smaller $\begin{cases} \text{number of} + signs \\ \text{number of} - signs \end{cases}$ p-value $= \sum_{i=0}^{S} (0.5)^i (0.5)^{(N-i)}$ where N = total number of experimental units	• Random samples • Independent observations • Variable needs to be ordinal	

Inference About: (Number of Samples)	**Name of Test**	**Test Statistic**	**Conditions**	**Nonparametric Options**
Mean (1 or 2 sample Matched Pairs)	**One-Sample t-Test**	$t = \frac{\bar{x}_d - \mu_d}{\frac{s_d}{\sqrt{n_d}}}$ $df = n_d - 1$	• Paired data from a random sample • Population of differences normally distributed OR number of pairs is large ($n_d > 30$)	Wilcoxon Signed Rank Test
Median (1 sample) **Nonparametric Test**	**Wilcoxon Signed Rank Test**	W= smaller $\begin{cases} \text{sum of positive ranks} \\ \text{sum of negative ranks} \end{cases}$	• Paired sample • Independent observations • Response variable must be at least ordinal • Distribution of differences symmetric about median	
Mean (2 samples) (Variances the same)	**Two-Sample (pooled) t-Test**	$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}}$ $s_p = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{S_1^2(n_1-1)+S_2^2(n_2-1)}{n_1+n_2-1}}}$ $df = n_1 + n_2 - 2$	• Random, independent samples from two populations • Both population distributions normally distributed OR both samples large ($n_1, n_2 > 30$) • Variances need to be the same* *Check the results of Levene's test to see if this condition is violated. If yes, use the adjusted results	Mann Whitney U-Test
Means (2 samples) (Variances NOT the same)	**Welch's Test**	$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_x^2}{n_2}}}$	• Same as above EXCEPT variances can be unequal	Mann Whitney U Test

Inferences About: (Number of Samples)	**Name of Test**	**Test Statistic**	**Conditions**	**Nonparametric Options**
Equality of Two Population Distributions **Nonparametric Test** (Can be used to compare means or medians only if two distributions have the same shape)	**Mann Whitney U test**	U= smaller (U_1, U_2) where $U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$ $U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$	• Random samples from two populations • Response (dependent) variable must be at least ordinal • Independent samples	
Means (Multiple Independent Samples)	**ANOVA**	$F = \frac{MS_{groups}}{MS_{error}}$ $= \frac{\frac{SS_{groups}}{k-1}}{\frac{SSerror}{n-k}}$ n=number of subjects k= number of groups OR $F = \frac{MS_{between}}{MS_{within}}$	• k random samples • Each population is normally distributed • Variances the same in all populations (robust if this is condition is violated)	Kruskal Wallis Test
Medians (Multiple Independent Samples) **Nonparametric Test**	**Kruskal Wallis Test**	$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \frac{R_j^2}{n_j} - 3(N+1)$	• k random samples • Independent samples • Response (dependent) variable must be at least ordinal • Distributions have same shape in each population	

Inference About: (Number of Samples)	Name of Test	Test Statistic	Conditions	Nonparametric Options
Means (Multiple Dependent Samples)	**Repeated Measures ANOVA**	$F = \frac{MS_{conditions}}{MS_{error}}$ OR $F = \frac{MS_{between}}{MS_{residual}}$	• k random samples • Same variable measured under different conditions on same subjects • Test variable follows a multivariate normal distribution • *Variances of all difference scores are equal Look at results of Mauchly's test. If significant, use Greenhouse Geisser correction if $GG < .75$, otherwise use Huynh-Feldt correction	Friedman's Test
Means (Multiple time points of dependent samples) **Nonparametric Test**	**Friedman's Test**	$Q = \frac{12n}{k(k+1)} \cdot \sum_{j=1}^{k} \left(\bar{r}_{ij} - \frac{k+1}{2}\right)^2$	• k random samples • Same variable measured under different conditions on same subjects • Variances of difference scores are equal	
Means (Examining the effects of two explanatory (independent) variables)	**Two Way ANOVA**	Calculate F_A, F_B, F_{AB} where $F_A = \frac{MS_A}{MS_{\text{within cell}}}$	• k random samples • Each population is normally distributed • Variances the same in all populations (robust if not)	

Inference About: (Number of Samples)	Name of Test	Test Statistic	Conditions	Nonparametric Options
Slope (Testing to see if slope of linear relationship is different from a given parameter value)	**Linear Regression t-Test**	$t = \frac{b-\beta}{SE_b}$ where SE_b is the standard error of the slope $SE_b = \sqrt{\frac{\frac{\sum(y_i-\hat{y})^2}{n-2}}{\sum(x_i-\bar{x})^2}}$ $df = n-2$	• Random sample • (x, y) pairs independent • There is a linear relationship between x and y • For each x, the y values are normally distributed with equal variances • For each y, the x values are normally distributed with equal variances	Spearman's Rank Correlation
Correlation (Test to see if the correlation between two numerical values is significant)	**Significance test on Pearson's Correlation Coefficient**	$t^* = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$ r = Pearson's correlation coefficient $r = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2(\sum(y_i-\bar{y})^2)}}$	• Random sample • (x, y) pairs independent • There is a linear relationship between x and y • For each x, the y values are normally distributed with equal variances • For each y, the x values are normally distributed with equal variances	Spearman's Rank Correlation
Correlation (Test to determome if the correlation between two variables (must be at least ordinal) is significant) **Nonparametric Test**	**Significance Test for Spearman's Rank Correlation**	$t = \frac{r_s\sqrt{n-2}}{\sqrt{1-r_s^2}}$ r_s is computed in the same way as r, but applied to ranks	• Random sample • (x, y) pairs are independent • Relationship between the variables is monotonic	

Post-hoc Test	Test Statistic	Conditions
Tukey's HSD (For all possible comparisons)	$HSD = \frac{\bar{x}_i - \bar{x}_j}{\sqrt{\frac{MS_w}{n}}}$ MS_w = Mean Squares Within n = number per treatment group	• Met Assumptions of ANOVA
Fisher's LSD (Does not correct for multiple comparisons)	$LSD_{ij} = t_{\alpha,dfW} \cdot \sqrt{MS_w \cdot (\frac{1}{n_i} + \frac{1}{n_j})}$	• Met assumptions of ANOVA
Dunn's Procedure / Bonferoni Correction	$t = \frac{\bar{x}_i - \bar{x}_j}{\sqrt{MS_w(\frac{1}{n_i} + \frac{1}{n_j})}}$ OR $F = \frac{(\bar{x}_i - \bar{x}_j)^2}{MS_w(\frac{1}{n_i} + \frac{1}{n_j})}$ Use $\alpha_i = \frac{\alpha}{C}$ C= Number of Comparisons	• Met assumptions of ANOVA
Cohen's D Effect Size Calculator	$d = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{S_1^2 + S_2^2}{2}}}$ if equal sample sizes Otherwise $d = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{S_1^2(n_1-1) + S_2^2(n_2-1)}{n_1+n_2-2}}}$	• Met assumptions of 2 sample t-test
Simple Effects Test	$t = \frac{\overline{AB}_{1j} - \overline{AB}_{2j}}{\sqrt{MS_{err} \cdot (\frac{1}{n_i} + \frac{1}{n_j})}}$	• Met assumptions of 2-way ANOVA