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Clear-Sighted Statistics: Appendix 3: Common Statistical Symbols and Formulas

Edward Volchok
CUNY Queensborough Community College

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Appendix 3: Common Statistical Symbols and Formulas

I. Introduction

This appendix lists common statistical symbols and formulas used in *Clear-Signed Statistics.* The terms and formulas presented here are explained in detail in the appropriate modules of *Clear-Sighted Statistics.*

II. Common Statistical Symbols and Formula

A. Module 4: Picturing Data with Tables and Charts

Symbol/Formula	Description
N	Number of observations, or items, in a population
n	Number of observations, or items, in a sample
k	Number of categories, classes, buckets, or bins in a Frequency Distribution
2 to the k formula	$2^k > n$. Formula used to determine the number of categories, classes, buckets, or bins in a Frequency Distribution
H	The highest value in a distribution
L	The smallest value in a distribution
Class Interval or Width, i	$i \geq \frac{H - L}{k}$
f	Frequency or the number of observations
RF or %	Relative frequency or the proportion of the total number of observations
Class Midpoint	$\text{Midpoint} = \frac{\text{Upper Class Limit} - \text{Lower Class Limit}}{2}$

Table 1: Module 4 Symbols and Formulas

B. Module 5: Statistical Measures

Symbol/Formula	Description
X	X stands for the random variable
Σ	Σ (capital Greek letter Sigma). It means the operation of summation or addition
$\bar{X}$ (The Sample Mean, X-Bar)	$\bar{X} = \frac{\Sigma X}{n}$, where X are the random variables

μ (The Population Mean, mu)	$\mu = \frac{\sum X}{N}$ where X are the random variables
$\bar{X}_W$ (Weighted Mean)	$\bar{X}_w = \frac{\sum wX}{\sum w}$ where X are the random variables and w are the weights
Median	M or Med or $\tilde{x}$ “x-tilde”
Mode	Mo
Range	Range = H (Highest Value) – L (lowest Value)
M, Med, or $\tilde{X}$	Median
Mean Deviation (MD) or Mean Absolute Deviation (MAD)	$MD = \frac{\sum\lvert X-\bar{X}\rvert}{n}$ where “| |” means the <u>absolute value</u>, the distance of a positive or negative number from zero, or the value of a number regardless of its negative or positive sign.
σ^2 (Population Variance, sigma-squared)	$\sigma^2 = \frac{\sum(X-\mu)^2}{N}$
s^2 (Sample Variance, s-squared)	$s^2 = \frac{\sum(X-\bar{X})^2}{n-1}$
σ (Population Standard Deviation, sigma)	$\sigma = \sqrt{\frac{\sum(X-\mu)^2}{N}}$
s (Sample Standard Deviation, s)	$s = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$
Sample Mean, Grouped Data	$\bar{X} = \frac{\sum fm}{n}$
Sample Standard Deviation, Grouped Data	$s = \sqrt{\frac{\sum f\,(M-X)^2}{n-1}}$
D	Stands for Decile. Deciles divide a distribution into ten groups of equal frequency
Location of a Decile	$L_D = (n+1)\frac{D}{10}$
P	Stands for Percentile. P75 or P_{75} means the 75^{th} percentile. Percentiles divide a distribution into a hundred groups of equal frequency.
Location of a Percentile	$L_P = (n+1)\frac{P}{100}$

Q	Stands for Quartile: Q_1 (1st Quartile), Q_2 (2nd Quartile), Q_3 (3rd Quartile) and Q_4 (4th Quartile). Quartiles divide a distribution into four groups of equal frequency.
Location of a Quartile	$L_Q = (n+1)\frac{Q}{4}$
Interquartile Range (IQR)	$IQR = 3rd\ Quartile - First\ Quartile$
Lower Outlier (Extreme Lower Outlier)	$Outlier < Q_1 + 1.5(Q_3 - Q_1)$ $Extreme\ Outlier < Q_1 + 3(Q_3 - Q_1)$
Upper Outlier (Extreme Upper Outlier)	$Outlier > Q_3 + 1.5(Q_3 - Q_1)$ $Extreme\ Outlier > Q_3 + 3(Q_3 - Q_1)$
Coefficient of Variation as a percentage	$CV = \frac{\sigma}{\mu}$ $CV = \frac{s}{\overline{X}}$
Coefficient of Variation as an index	$CV = \frac{\sigma}{\mu} * 100$ $CV = \frac{s}{\overline{X}} * 100$
Skewness or SK	$SKmode = \frac{\overline{X} - Mode}{std.dev}$ $SKmedian = \frac{\overline{X} - Median}{std.dev}$
Pearson's Coefficient of Skewness	$Coefficient\ of\ Skewness = \frac{3(\overline{X} - Md)}{s}$
Trimean	$Trimean = \frac{Q1 + (2 * Q2) + Q3}{4}$

Table 2: Module 5 Descriptive Statistics Measures

C. Module 6: Index Numbers

Symbol/Formula	Description
Simple Index Number	$P = \frac{P_t}{P_o}(100)$
Simple Price Index	$P = \frac{\Sigma Pi}{n}$

Simple Aggregate Price Index	$P = \frac{\Sigma Pt}{\Sigma Po} * 100$
Laspeyres Index	$P_L = \frac{\Sigma P_t Q_O}{\Sigma P_O Q_O} * 100$
Paasche Index	$P_P = \frac{\Sigma P_t Q_t}{\Sigma P_O Q_t} * 100$
Fisher's Ideal Index	$P_F = \sqrt[n]{(\text{Laspeyres}) * (\text{Paasche})}$
Value Index	$V = \frac{\Sigma P_t Q_t}{\Sigma P_o Q_o} * 100$

Table 3: Module 6: Index Numbers

D. Module 7: Basic Concepts of Probability

Symbol/Formula	Description
P(A)	The probability of event "A"
P(~A)	The probability of the event not A. This is called the complement of event A. It is sometimes written as $P(A^C)$ or P(not A).
P(A|B)	The probability of event A given than event B has happened. This is called conditional probability.
Special Rule of Addition (for mutually exclusive events)	P(A or B) = P(A) + P(B) or $P(A \cup B) = P(A) + P(B)$ **Note:** ∪ is pronounced "union" and is the equivalent to the word "or"
Complement Rule (Subtraction Rule)	P(A) = 1 − P(~A)
General Rule of Addition (for non-mutually exclusive events	P(A or B) = P(A) + P(B) − P(A and B) or $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ **Note:** ∩ is pronounced as "intersection." It is the equivalent to the word "and."
Special Rule of Multiplication (for independent events	P(A and B) = P(A)P(B) or $P(A \cap B) = P(A)P(B)$
General Rule of Multiplication (for dependent events	P(A and B) = P(A)P(B|A) or $P(A \cap B) = P(A)P(B\|A)$

Bayes Theorem	$P(A_1\|B) = \frac{P(A_1)P(B\|A_1)}{P(A_1)P(B\|A_1) + (A_2)P(B\|A_2)}$
Multiplication Formula	$\text{Total Arrangements} = (m)(n)(o)$
Factorial Number	n! (The factorial of a non-negative integer n, denoted by n!, is the product of all positive integers less than or equal to n: 4! = 1 x 2 x 3 x 4 = 24.)
Permutations	$_nP_r = \frac{n!}{(n-r)!}$
$_nP_r$	$_nP_r$ is pronounced "the permution of r things selected from n things." **Note:** With permutations, the order of selection matters.
Combinations	$_nC_r = \frac{n!}{r!(n-r)!}$
$_nC_r$	$_nC_r$ is pronounced "the combination of r things selected from n things." **Note:** With combinations, the order of selection matters.

Table 4: Module 7: Basic Concepts of Probability

E. Module 8: Discrete Probability Distributions

1) Mean of a Probability Distribution, μ

□$\mu = \Sigma[xP(x)]$, found by multiplying each value by its probability and then adding the product of each value times its probability.

2) Variance of a Probability Distribution, σ^2

$\sigma^2 = \Sigma[(X - \mu)^2P(x)]$, found by, 1) Subtract the mean from each random value, x, 2) Square $(x - \mu)$, 3) Multiply each square difference by its probability, and 4) Sum the resulting values to arrive at σ^2.

3) Standard Deviation of a Probability Distribution, σ

$\sigma = \sqrt{\sigma^2}$, the standard deviation is the positive square root of variance.

4) Binomial Probability Formula

$P(x) = nCx\pi^x(1 - \pi)^{n-x}$, where C denotes combinations, n is the number of trials, x is the random number of successful trials, π is the probability of a success for each trial. Note: π, or pi, is not the mathematical constant of 3.14159 that you used in your geometry class to find the circumference of a circle.

5) Mean of a Binomial Distribution

$\mu = n\pi$

6) Variance of a Binomial Distribution

$\mu = n\pi(1 - \pi)$

7) Hypergeometric Distribution

$$P(x) = \frac{({}_{S}C_{x})({}_{N-S}C_{n-x})}{{}_{N}C_{n}}$$

Where N is the size of the population; S is the number of successes in the population; x is the number of successes (It could be 0, 1, 2, 3, 4, …); n is the size of the sample (number of trials); and C is the combinations.

8) Poisson Distribution

$$P(x) = \frac{\mu^{x} e^{-\mu}}{x!}$$

Where μ is the mean number of successes in a particular interval; e is the constant or base of the Naperian logarithmic system, 2.71828’ x is the number of successes; and P(x) is the probability of a specified value of x.

9) Mean of a Poisson Distribution

$\mu = n\pi$

F. Module 9: Continuous Probability Distributions

Symbol/Formula	Description
Standard Normal Value	$z = \frac{X - \mu}{\sigma}$
Standard Error for the Mean, sigma sub x-bar or SEM	$\sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$
z-value, μ and σ known	$z = \frac{\bar{X} - \mu}{\sigma / \sqrt{n}}$
Solving for X	$X = \mu + z\sigma$ **Note:** z can be either a positive or negative number.

Table 5: Module 9: Continuous Probability Distribution

G. Module 10: Sampling and Sampling Errors

Symbol/Formula	Description
Mean of the Sample Means (mu sub x-bar)	$\mu_{\bar{X}} = \frac{\text{Sum of all sample means}}{\text{Total number of samples}}$
Sampling Error	$\bar{X} - \mu = 0$ or $\bar{X} \neq \mu$
z-value for sample	$z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$
Standard Error of the Mean, SEM, or $\sigma_{\bar{X}}$	$\sigma_{\bar{X}} = \sigma/\sqrt{n}$

Table 6: Module 10: Sampling and Sampling Errors

H. Module 11: Confidence Intervals

Symbol/Formula	Description
c	The selected confidence level; usually 95%, but in some cases 99% or 90%.
Critical Value	The value a test statistic must exceed to be out of the confidence interval or the value a test statistics must exceed to reject the Null Hypothesis. A test statistic is a value derived from a sample for the purposes of hypothesis testing and confidence intervals. Do not report the Critical Value as CV. CV is the Coefficient of Variance.
z_c	The critical value for a confidence level using z values.
t_c	The critical value for a confidence level using t values.
Confidence Interval for Means using z	$\bar{X} \pm z\frac{\sigma}{\sqrt{n}}$
Margin of Error for the Mean using z	$z\frac{\sigma}{\sqrt{n}}$
d.f., df, or ν (the lower-case or small Greek letter nu)	Note: The formula for degrees of freedom depends on the type of distribution used.
Confidence Interval for Means using t	$\bar{X} \pm t\frac{s}{\sqrt{n}}$
Margin of Error for the Mean using t	$t\frac{s}{\sqrt{n}}$
Sample Proportion, p	Sample Proportion = p (a lower-case p). A commonly used symbol for the sample proportion is p-hat, $\hat{p}$.
Sample Proportion formula	$p = \frac{X}{n}$

Population Proportion	Population Proportion = π. Some use a capital P to symbolize the Population Proportions. In *Clear-Sighted Statistics* population parameters are always symbolized with Greek letters.
Standard Error for the Proportion (σ_p, SEP or SE_P)	$SEP\sqrt{\frac{p(1-p)}{n}}$
Confidence Interval for Proportions	$z\sqrt{\frac{p(1-p)}{n}}$

Table 7: Module 11: Confidence Intervals

I. Module 12: Estimating Sample Size

Symbol/Formula	Description
Estimating Sample Size for the Mean	$n = \left(\frac{z\sigma}{E}\right)^2$
Estimating Sample size for the Proportion	$n = p(1-p)\left(\frac{z}{E}\right)^2$

Table 8: Module 12: Estimating Sample Size

J. Module 13: Introduction to Null Hypothesis Significance Testing

Symbol/Formula	Description
H_0	The Null Hypothesis. H_0 is pronounced "H sub-zero" or "H sub naught." H_0 is a hypothesis about a population parameter. The Null Hypothesis states that there is no effect. Any difference between the parameter and the statistic is due to sampling error.
H_1 or H_A	The Alternate Hypothesis, sometimes called the Research Hypothesis. The Alternate Hypothesis is pronounced "H sub-one" when the H_1 symbol is used or "H sub-A" when the H_A symbol is used. Like the Null Hypothesis, the Alternate Hypothesis is a statement about a population parameter. The Alternate hypothesis states that there is an effect, which means the difference between the parameter and statistic is too big to have occurred by chance.
α (alpha)	The level of significance. The level of significance is selected by the researcher or analyst. Alpha is also the likelihood of a Type I Error.
P(α)	The probability of a Type I Error, or rejecting a Null Hypothesis when we should fail to reject it.
β (beta)	A Type II Error or failing to reject a Null Hypothesis that should be rejected.

p-value	The p-value represents the likelihood of obtaining a test statistic as extreme or more extreme than the one obtained. If the p-value is greater than the level of significance, fail to reject the Null Hypothesis. When the p-value is equal to or less than the level of significance, reject the Null Hypothesis.

Table 9: Module 13: Introduction to Null Hypothesis Significance Testing

K. Module 14: One-Sample Tests of Hypothesis (Normal and Student *t* Distributions)

Symbol/Formula	Description
One-Sample test for the Mean when σ is known	$z = \frac{\bar{X} - \mu}{\sigma/\sqrt{n}}$
One-Sample test for the Mean when σ is unknown	$t = \frac{\bar{X} - \mu}{s/\sqrt{n}}$
One-Sample test for the Proportion	$z = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}}$
Probability of a Type II Error P(β)	$z = \frac{\bar{X}_c - \mu_1}{\sigma/\sqrt{n}}$
Power of a Test	$\text{Power of a Test} = 1 - P(\beta)$
Cohen's d Effect Size	$\text{Cohen's d Effect Size} = \frac{\lvert\bar{X} - \mu\rvert}{\sigma}$
delta, δ, for the mean	$\gamma = \frac{\lvert\mu_1 - \mu_0\rvert}{\sigma}$ $\delta = \gamma\sqrt{n}$
delta, δ, for the proportion	$\gamma = \frac{\lvert\pi_1 - \pi_0\rvert}{\sqrt{\pi_0(1-\pi_0)}}$ $\delta = \gamma\sqrt{n}$

Table 10: Module 14: One-Sample Tests of Hypothesis

L. Module 15: Two-Sample Tests of Hypothesis (Normal and Student *t* Distributions)

Symbol/Formula	Description
Variance of the Distribution of differences in Means	$\sigma^2_{\bar{X}_1 - \bar{X}_2} = \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}$
Two-sample z-test of Means	$z = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$

Pooled Standard Deviations	$\text{Pooled Standard Deviation} = \sqrt{\frac{s_1^2 + s_2^2}{2}}$
Cohen's d	$\text{Cohen's d} = \frac{\lvert \bar{X}_1 - \bar{X}_2 \rvert}{\text{Pooled Standard Deviation}}$
Cohen's h (ES for population)	$\text{Cohen's h} = \lvert \phi_1 - \phi_2 \rvert, \text{where phi } (\phi) = 2(\arcsin * \sqrt{p})$
Pooled Proportion	$p_c = \frac{X_1 + X_2}{n_1 + n_2}$
Two-sample z-test of Proportions	$z = \frac{p_1 - p_2}{\sqrt{\frac{p_c(1-p_c)}{n_1} + \frac{p_c(1-p_c)}{n_2}}}$
Pooled Variance t-test for Means (equal Variance)	$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$
Pooled Variance	$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{s_p^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$
F-Test for comparing two sample variances	$F = \frac{s_1^2}{s_2^2}$
Two-Sample t-test for Means (Unequal Variance)	$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$
df for Unequal Variance t-test	$df = \frac{[(s_1^2/n_2) + (s_2^2/n_2)]}{\frac{(s_1^2/n_1)^2}{n_1 - 1} + \frac{(s_2^2/n_2)^2}{n_2 - 1}}$
d	The difference between paired or dependent samples.
$\bar{d}$	The mean of the difference between paired or dependent samples.
Paired t-test for dependent samples	$t = \frac{\bar{d}}{s_d/\sqrt{n}}$

Table 11: Module 15: Two-Sample Tests of Hypothesis

M. Module 16: ANOVA

Symbol/Formula	Description

Sum of Square, total	$\text{Total} = \sum (X - \overline{X}_G)^2$
Sum of Square, error	$\text{Within (SSW)} = \sum (X - \overline{X}_c)^2$
Sum of Square, treatment	$\text{Between (SSB)} = \text{Total} - \text{SSW}$
Eta-squared, η^2, Effect Size	$\eta^2 = \frac{\text{SSB}}{\text{Total}}$
Confidence Interval for difference in Treatment Means	$(\overline{X}_1 - \overline{X}_2) \pm t\sqrt{\text{MSE}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$

Table 12: Module 16 ANOVA

N. Module 17: Chi-Square Tests

Symbol/Formula	Description
Chi-Square (χ^2) Goodness of Fit Test	$\chi^2 = \sum \left[\frac{(f_o - f_e)^2}{f_e}\right]$ Where f_o stands for the Observed Frequencies for each category and f_e stands for the Expected Frequencies for each category.
Chi-Square Expected Frequency for a Contingency Table	$f_e = \frac{(\text{Row Total})/(\text{Column Total})}{\text{Grand Total}}$
Cohen's w Effect Size	$\text{Cohen's } w = \sqrt{\frac{\chi^2}{n}}$
Degrees of Freedom for a Goodness of Fit	df = k – 1
Degrees of Freedom for a contingency table	$df = (\text{\# of rows} - 1)(\text{\# of columns} - 1)$
Degrees of Freedom for a Goodness of Fit test for Normality	df = k – 3 (The two extra degrees of freedom are needed because we use the sample mean and sample standard deviation.)

Table 13: Module 17 Chi-Square Tests

O. Module 18: Linear Correlation and Regression

Symbol/Formula	Description
Coefficient of Correlation or r	$r = \frac{\sum (X - \overline{X})(Y - \overline{Y})}{(n-1)s_X s_Y}$

Coefficient of Determination or r^2	r^2 or $r^2 = \frac{SSR}{SS\ total} = 1 - \frac{SSE}{SS\ total}$
Test for the significance of r	$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$
ρ, or the lower-case Greek letter rho	$\rho = \frac{\sum(X-\mu_X)(Y-\mu_Y)}{(n)\sigma_X\sigma_Y}$
Linear Regression Equation (y-hat)	$\hat{Y} = a + bX$
Slope of the Regression Line	$b = r\frac{s_Y}{s_X}$
Intercept of the Regression Line	$a = \bar{Y} - b\bar{X}$
Test for Zero Slope	$t = \frac{b-0}{s_b}$
Standard Error of the Estimate	$s_{Y\bullet X} = \sqrt{\frac{\sum(Y-\hat{Y})^2}{n-2}}$
Confidence Interval	$\hat{Y} \pm t(s_{Y\bullet X})\sqrt{\frac{1}{n} + \frac{(X-\bar{X})^2}{\sum(X-\bar{X})^2}}$
Prediction Interval	$\hat{Y} \pm t(s_{Y\bullet X})\sqrt{1 + \frac{1}{n} + \frac{(X-\bar{X})^2}{\sum(X-\bar{X})^2}}$

Table 14: Module 18 Linear Correlation and Regression

P. Microsoft Excel Statistical Functions

Analysis ToolPak

Anova: Single Factor

Correlation

Descriptive Statistics

F-Test Two-Sample for Variance

Histogram

Moving Average

Rank and Percentile

Regression

Sampling

t-Test: Paired Two Samples for Means

t-Test: Two-Sample Assuming Equal Variances

t-Test: Two-Sample Assuming Unequal Variances

z-Test: Two Sample for Means

Math Functions

ABS, POWER, ROUND, ROUNDDOWN, ROUNDUP, SQRT, SUM, SUMIF, SUMIFS, SUMPRODUCT, SUMSQ

Frequency Distribution Functions:

FREQUENCY

Descriptive Statistics Functions:

AVEDEV, AVERAGE, AVERAGEA, AVERAGEIF, AVERAGEIFS, COUNT, COUNTA, COUNTBLANK, CCOUNTIF, COUNTIFS, FREQUENCY, GEOMEAN, HARMEAN, KURT, LARGE, MAX, MAXA, MAXIFS, MEDIAN, MIN, MINA, MINIFSM MODE.MULT, MODE.SNGL, PERCENTILE.EXC, PERCENTILE.INC, PRECENTRANK.EXC, PERCENTRANK.INC, QUARTILE.EXC, QUARTILE.INC, RANK.AVG, RANK.EQ, SKEW, SKEW.P, SMALL, STDEV.P, STEVA, STDEVPA STDEV.S, VAR.P, VAR.S

Probability Functions:

COMBIN, FACT, PERMUT, PROB

Binomial Distribution Functions:

BINOM.DIST, BINOMI.INV

Exponential Distribution Functions:

EXPON.DIST

Hypergeometric Distribution Functions:

HYPOGEOM.DIST

Poisson Distribution Functions:

POISSON.DIST,

Normal Distribution Functions:

NORMAL.DIST, NORM.INV, NORM.S.INV, NORM.SINV, STANDARDIZE

t Distribution Functions:

T.DIST, T.DIST.2T, T.DIST.RT, T.INV, T.INV.2T, and T.TEST

Confidence Interval Functions:

CONFIDENCE.NORM and CONFIDENCE.T

F Distribution Functions:

FDIST, FDISTRT, FINV, FINVRT

Chi-Square Functions:

CHISQ.DIST, CHISQ.DISTRT, CHISQ-INV, and CHISQ-INVRT

Exponential Distribution Functions:

EXPON.DIST

Correlation and Regression Functions:

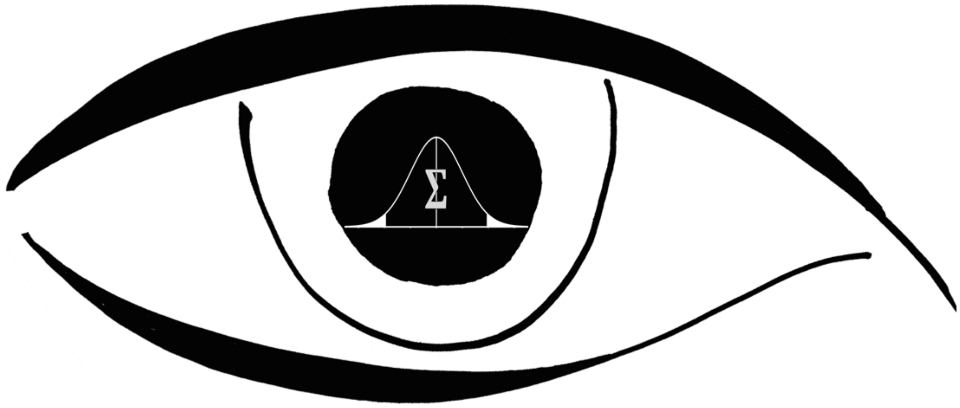
CORREL, DEVEQ, INTERCEPT, LINEST, PEARSON, RSQ, SLOP, STEYX, TREND

Q. Greek Letters Commonly Used in Statistics

Greek Letter	Upper Case	Lower Case	Statistical Symbol
Alpha	A	α	α = level of significance, Type I Error

Beta	Β	β	β = Type II Error; 1 – β = Power of the test
Gamma	Γ	γ	
Delta	Δ	δ	
Epsilon	Ε	ε	
Zeta	Ζ	ζ	
Eta	Η	η	
Theta	Θ	θ	
Iota	Ι	ι	
Kappa	Κ	κ	
Lambda	Λ	λ	
Mu	Μ	μ	μ = population mean
Nu	Ν	ν	ν = degrees of freedom (df)
Xi	Ξ	ξ	
Omicron	Ο	ο	
Pi	Π	π	π = population proportion
Rho	Ρ	ρ	ρ = linear correlation of a population
Sigma	Σ	σ	Σ = "Sum of" or summation; σ^2 = population variance; σ = population standard deviation
Tau	Τ	τ	
Upsilon	Υ	υ	
Phi	Φ	φ	
Chi	Χ	χ	Chi Square statistics (χ^2)
Psi	Ψ	ψ	
Omega	Ω	ω	

CLEAR-SIGHTED STATISTICS



EDWARD VOLCHOK

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