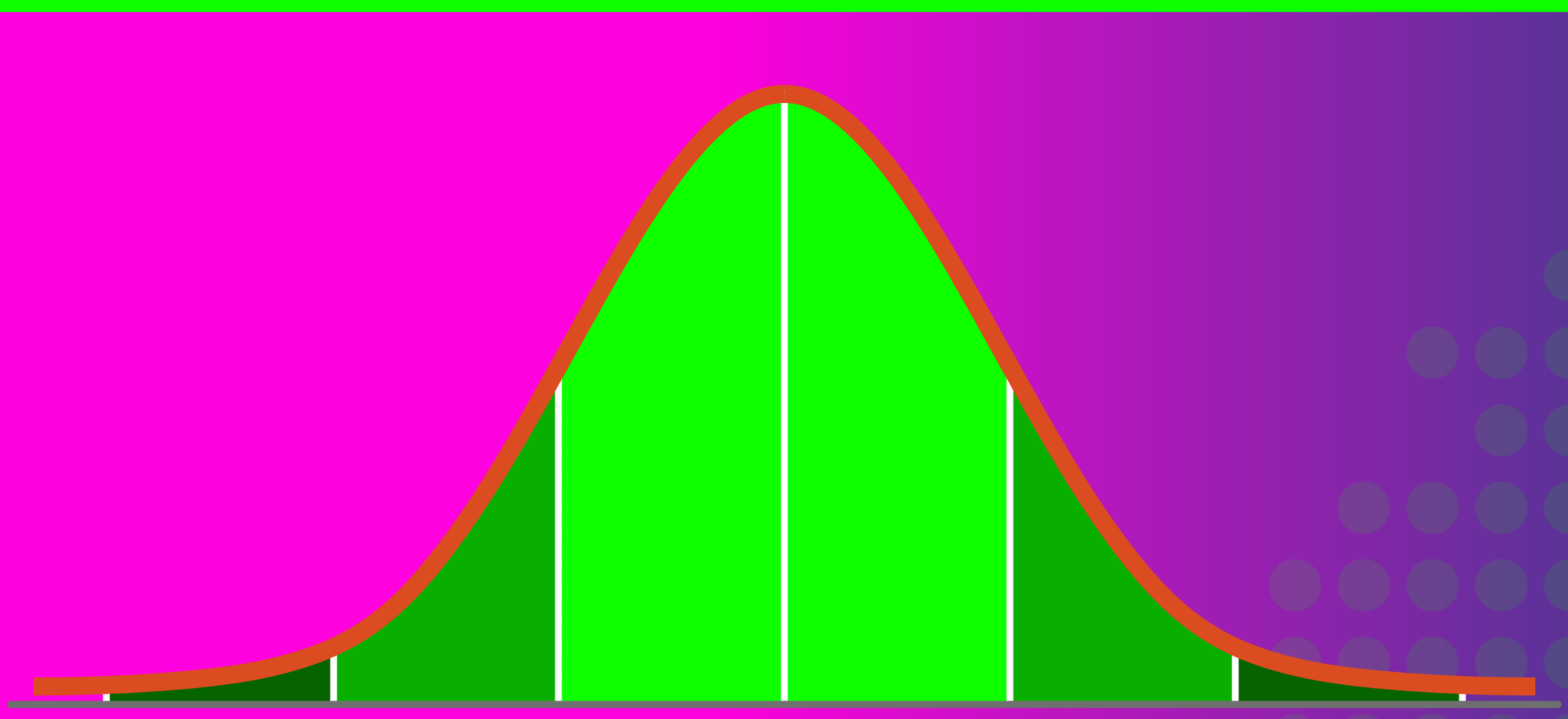
WHICH TEST WHEN?

The Data Analyst's Guide to Understanding Data Types, Distributions, and Statistical Tests.



ANDREW MADSON

WHAT WILL YOU LEARN?

DATA TYPES

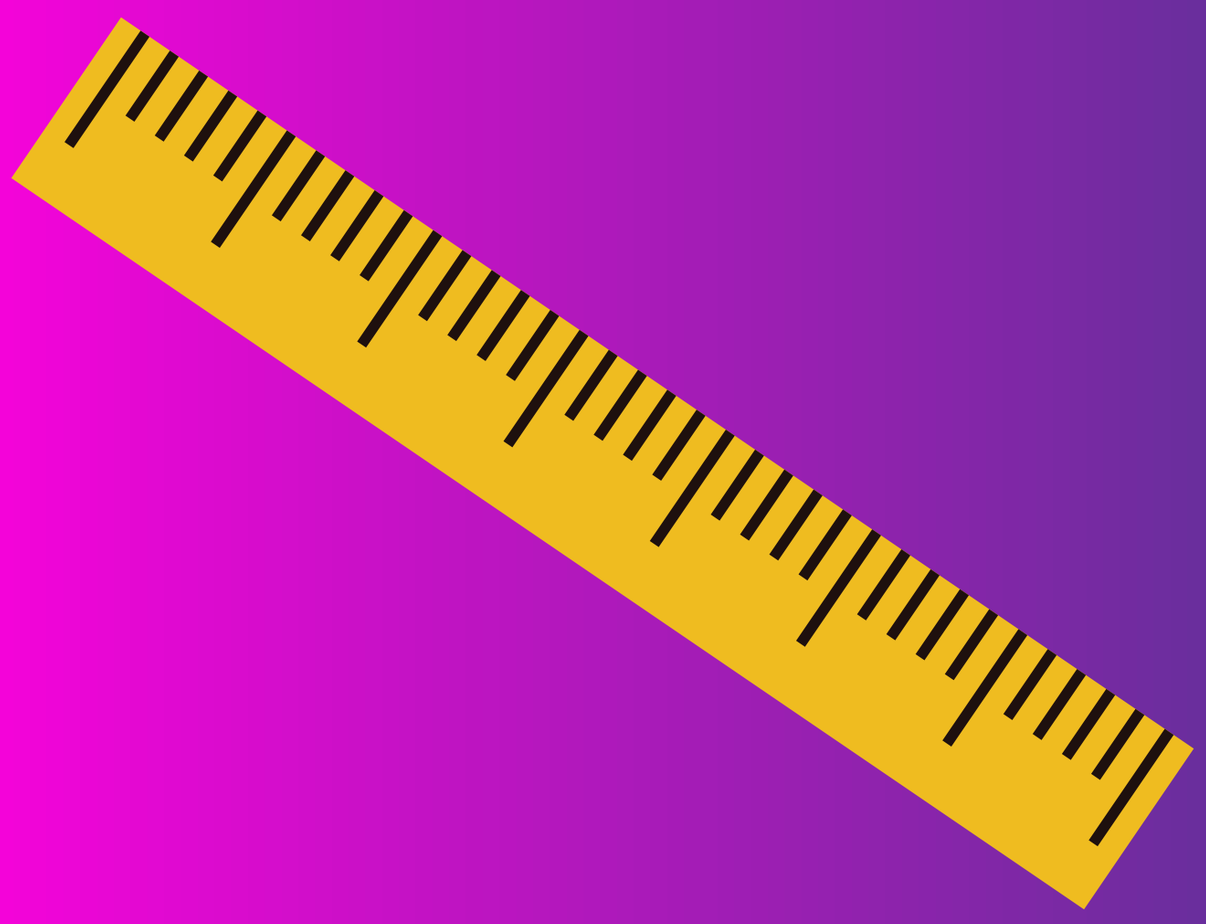
↓

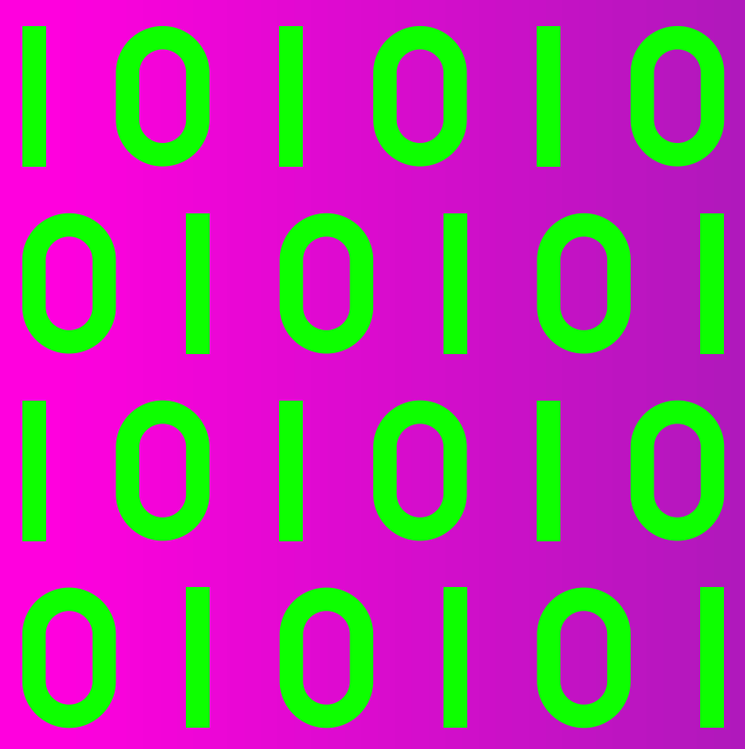
DISTRIBUTIONS

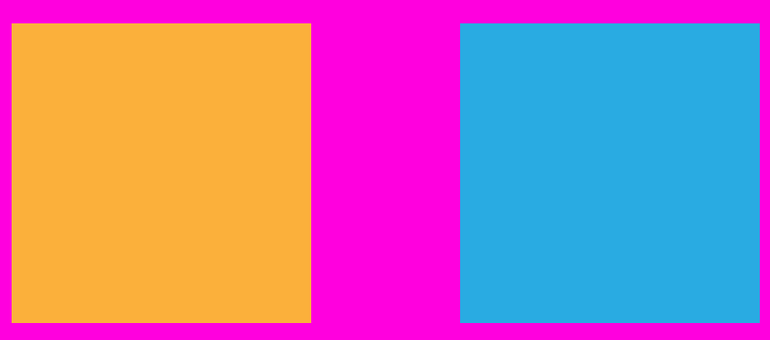
↓

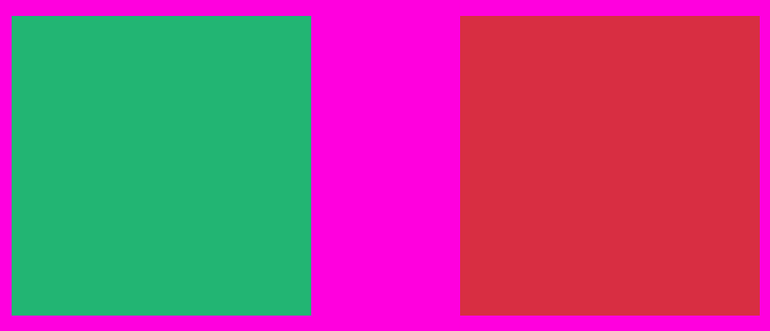
STATISTICAL TESTS

DATA TYPES









DATA TYPES

WHY IT MATTERS

1. Appropriate Analysis: Different types of data require different statistical tests. For example, nominal data can be analyzed using a Chi-square test, while interval data can be analyzed using a t-test or ANOVA. Using the wrong test can lead to incorrect conclusions.

2. Data Visualization: Your data type determines the best way to visualize it. For instance, categorical data might be best represented in a bar chart, while continuous data might be better suited for a histogram or scatter plot.

3. Data Transformation: Understanding your data type can guide you in transforming your data, if necessary. For example, ordinal data might be converted into interval data under certain conditions, or continuous data might be categorized into ordinal data.

4. Data Quality: Knowing your data type can help you identify potential errors or inconsistencies in your data. For instance, if you expect a variable to be continuous and find string values, this could indicate a data quality issue.

5. Interpretation of Results: The type of data you have influenced how you interpret your results. For example, if you have ordinal data, you can make statements about the order of values but not the difference between values.





DATA TYPES

QUANTITATIVE

Numerical data that can be measured or counted and can be represented numerically, such as height, weight, or temperature.

QUALITATIVE

Non-numerical data that consists of descriptive information, such as colors, tastes, textures, or any other characteristics that cannot be counted or measured.

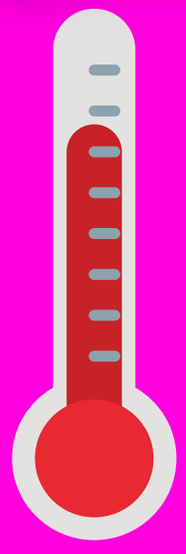
DATA TYPES

QUANTITATIVE

DISCRETE

CONTINUOUS

INTERVAL



RATIO

QUANTITATIVE DATA TYPES

DISCRETE	**Distinct and separate values with no intermediate values in between.**
CONTINUOUS	**Infinitely divisible and can take on any value within a certain range or interval. Encompasses both INTERVAL and RATIO data.**
INTERVAL	**Continuous Data Type - numerical data where the intervals between values are equal but no true zero point exists.**
RATIO	**Continuous Data Type - numerical data with a true zero point, allowing for meaningful ratios and comparisons between values.**

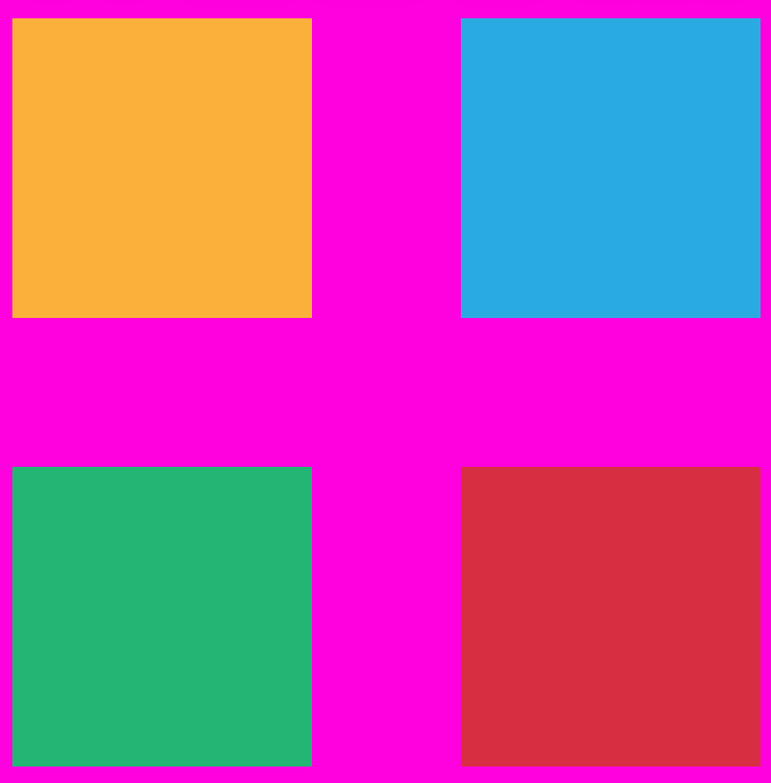




DATA TYPES

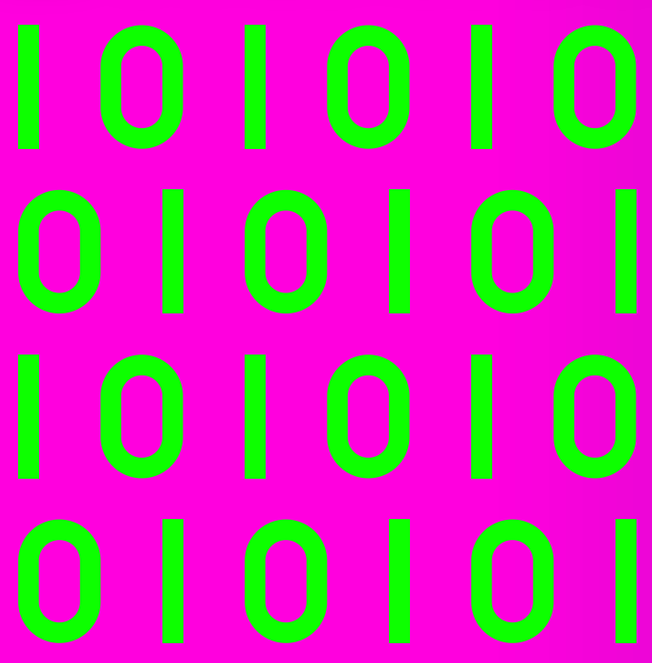
QUALITATIVE

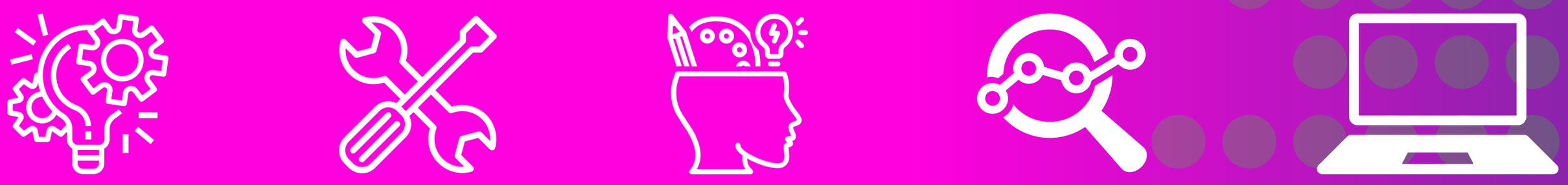
CATEGORICAL



ORDINAL

BINARY





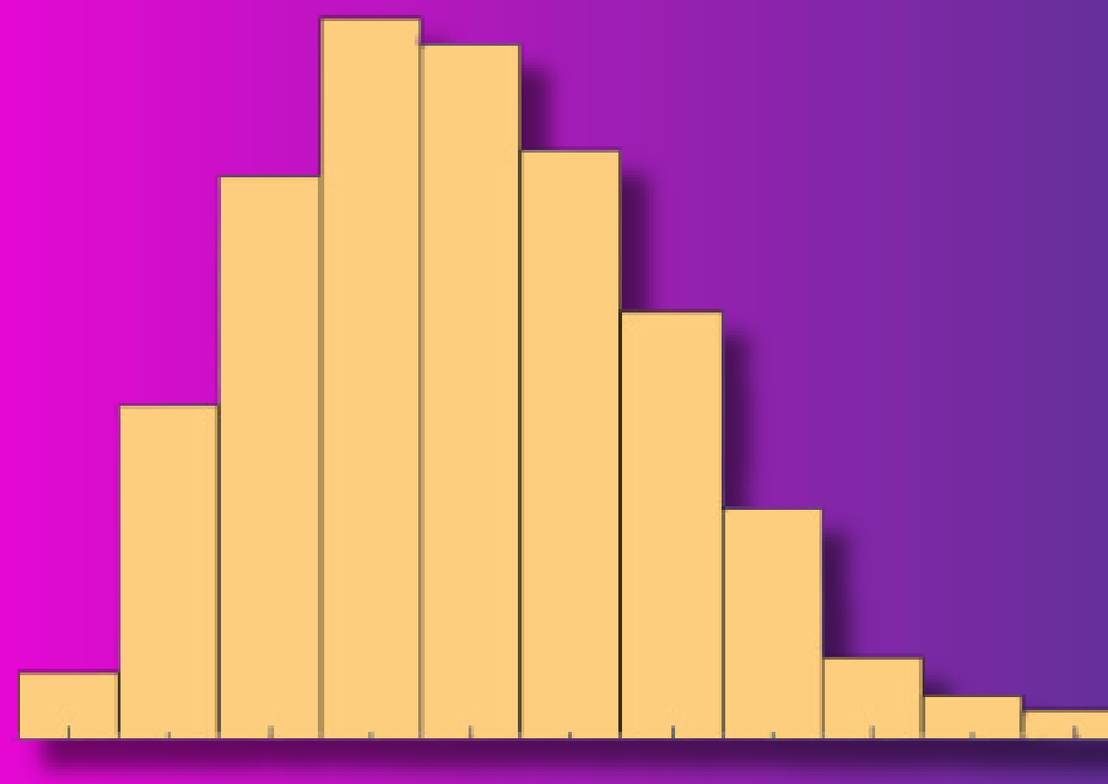
QUALITATIVE DATA TYPES

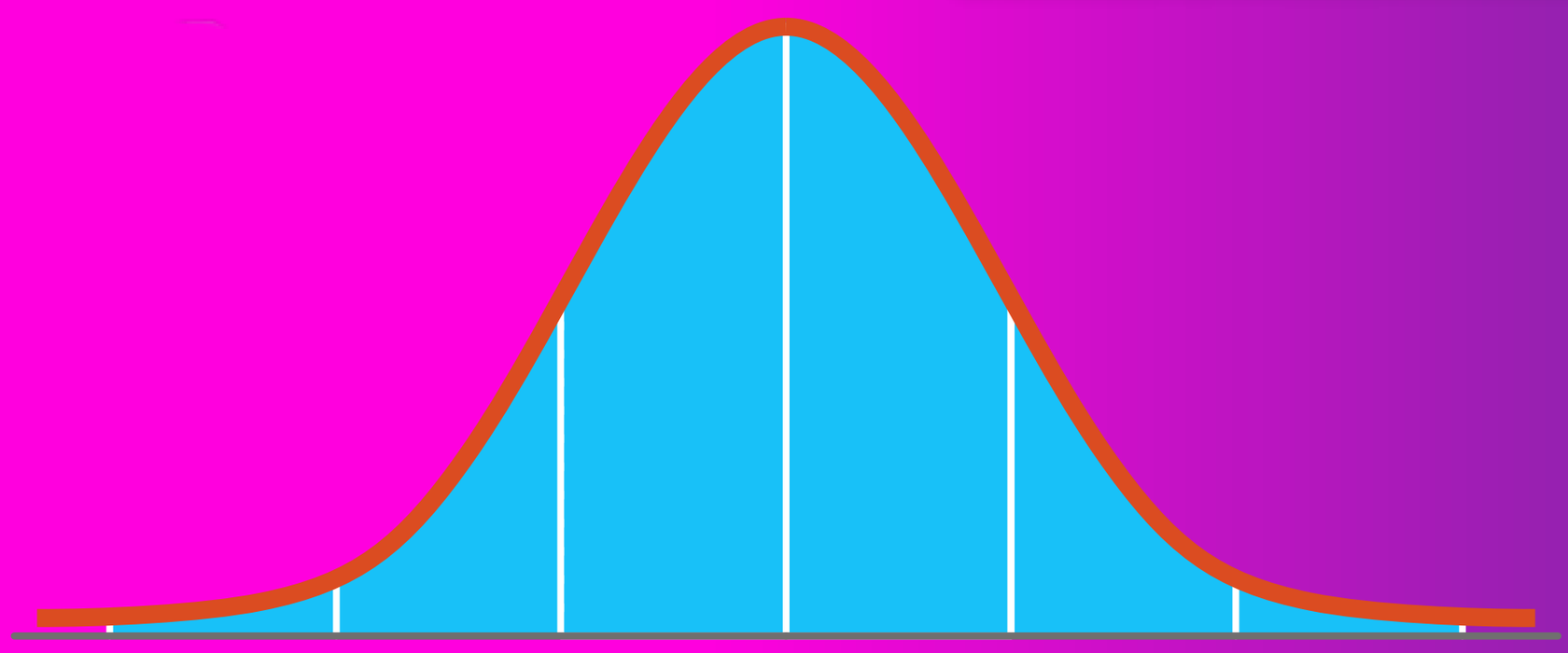
CATEGORICAL	**Distinct categories or groups with no inherent order or numerical significance.**
ORDINAL	**Data with a natural order or ranking among its categories, indicating relative differences or preferences.**
BINARY	**Categorical data that has only two possible outcomes or categories.**

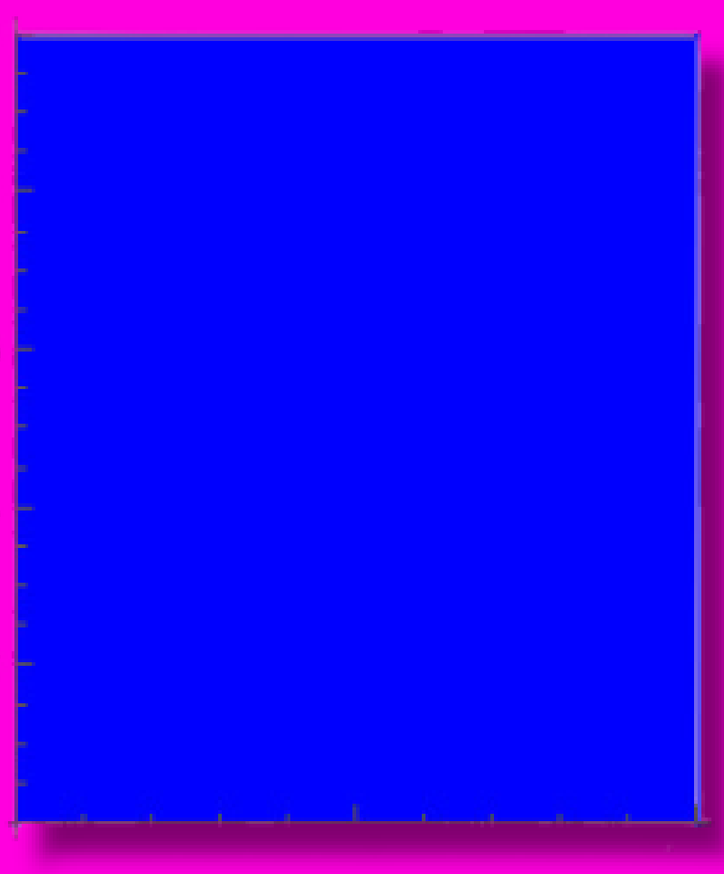


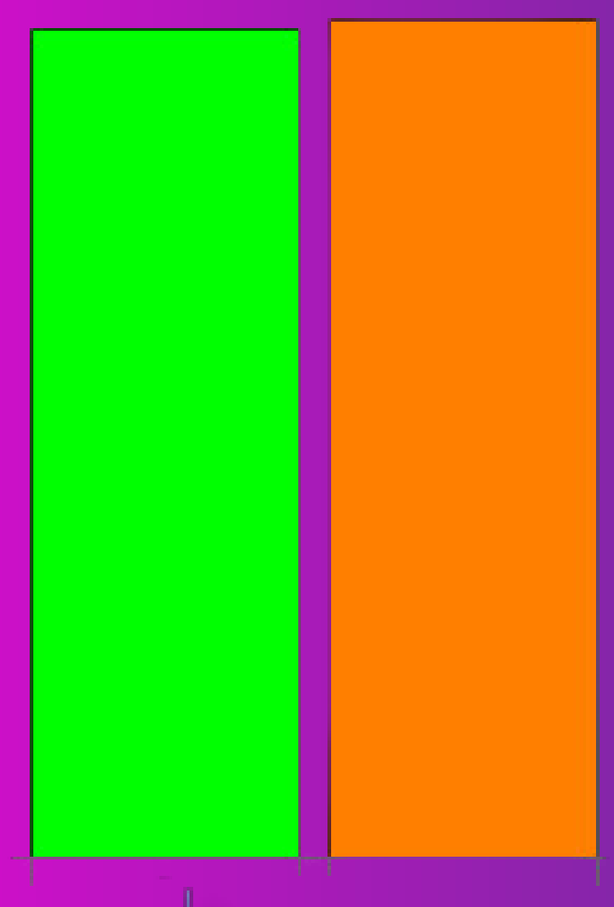


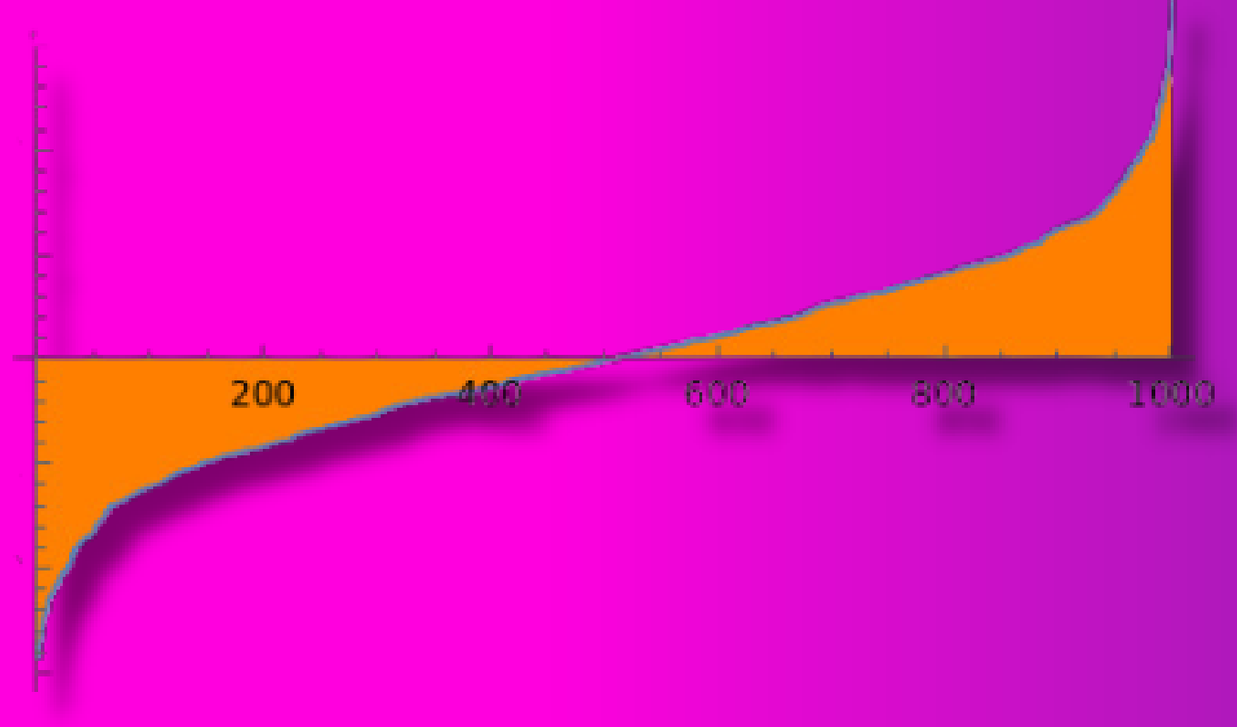
DISTRIBUTIONS











DISTRIBUTION TYPES

WHY IT MATTERS

1. **Understanding the data: Understanding the distribution of your data gives insight into the nature and behavior of the variables you are studying. It helps you identify your data's patterns, trends, and potential outliers.**
2. **Statistical assumptions: Many statistical tests and models make assumptions about the distribution of the data. For example, the t-test assumes that the data follows a normal distribution. If these assumptions are violated, it can lead to incorrect conclusions. Knowing the distribution of your data helps you choose the appropriate statistical methods.**
3. **Predictive modeling: When building predictive models, the distribution of the data can inform the selection of algorithms or the model's configuration. Some machine learning algorithms are more suited to certain types of distributions.**
4. **Data transformation: If your data does not follow the distribution required by a particular statistical method, you may need to transform it. For example, if your data is skewed, you might apply a logarithmic transformation to make it more symmetrical. Understanding the distribution can guide these transformations.**
5. **Risk management: In fields like finance and insurance, understanding data distribution is crucial for risk assessment. For example, the distribution of returns on investment can help determine the probability of a significant loss.**
6. **Data quality: Examining data distribution can also be a way to check data quality. If the data doesn't follow expected distributions, it may indicate errors or bias in the data collection process.**

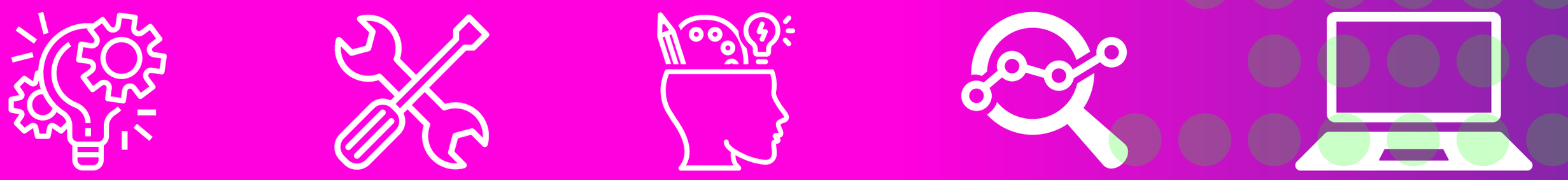
DISTRIBUTION TYPES

PARAMETRIC

Assume that the data follows a certain specific distribution pattern, and the parameters of that distribution are estimated from the data.

NON-PARAMETRIC

Do not assume that the data follow any specific distribution. They are defined without the assumption of underlying parameters

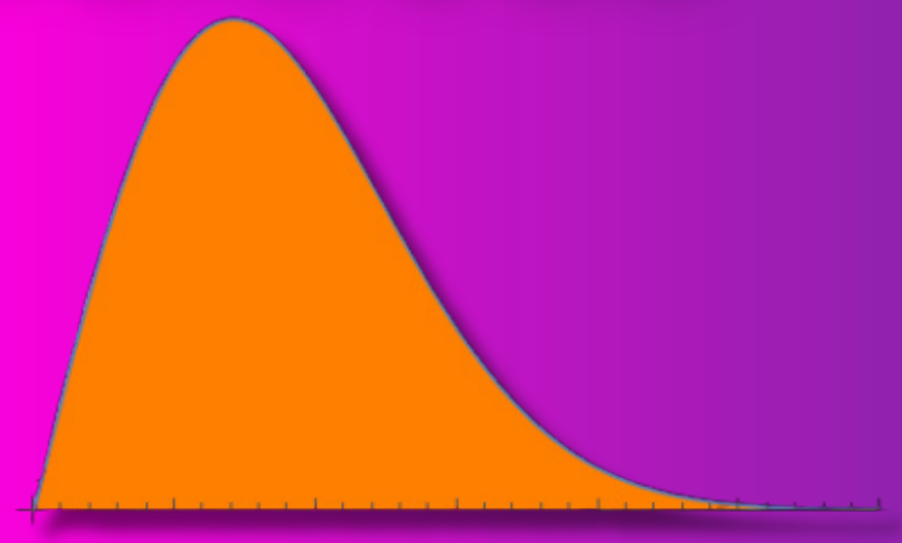


DISTRIBUTION TYPES

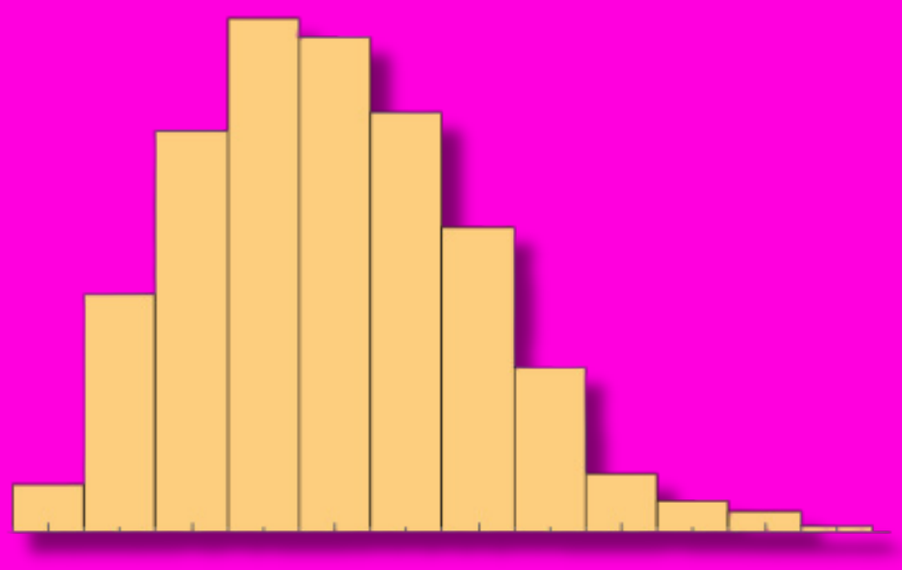
PARAMETRIC

NORMAL

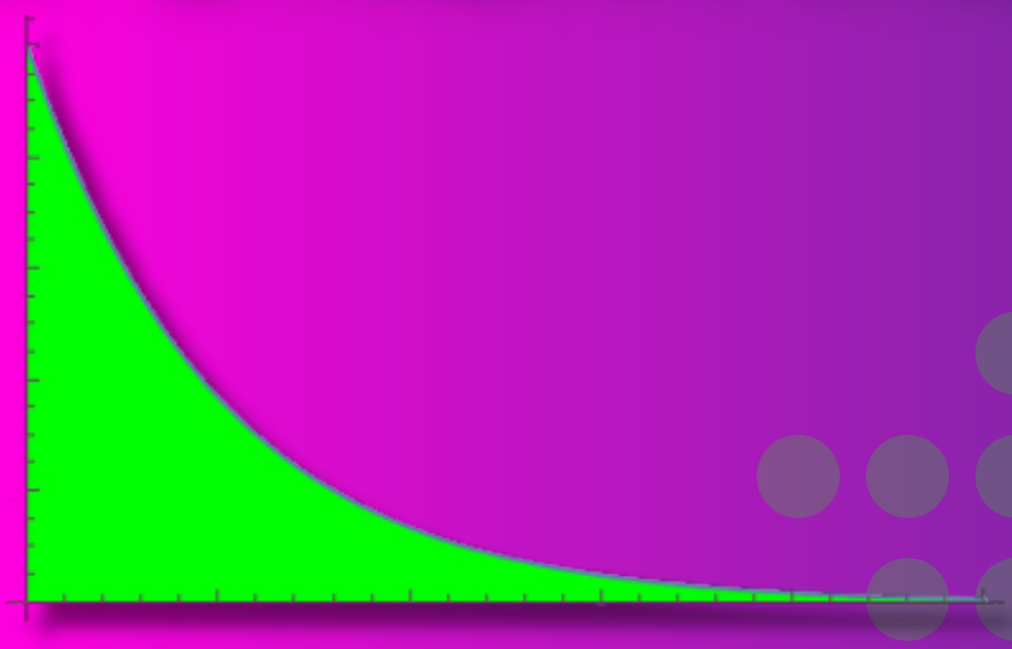
WEIBULL



POISSON



EXPONENTIAL



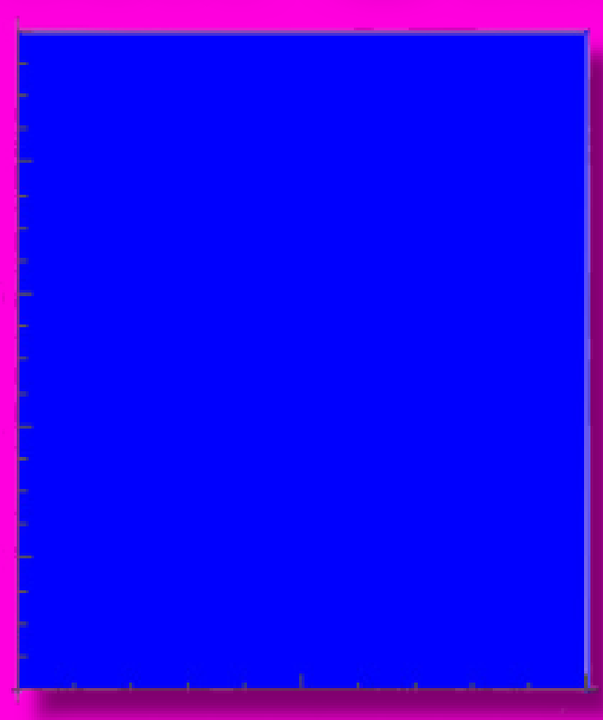
PARAMETRIC DISTRIBUTIONS

NORMAL	Symmetric around the mean, showing that data near the mean are more frequent in occurrence than data far from the mean.
WEIBULL	Continuous probability distribution that models the time it takes for an event to occur and is commonly used in reliability and survival analysis.
POISSON	Discrete probability distribution that models the number of events occurring in a fixed interval of time or space.
EXPONENTIAL	Continuous probability distribution that models the time between events in a Poisson process, where events occur independently and at a constant average rate.

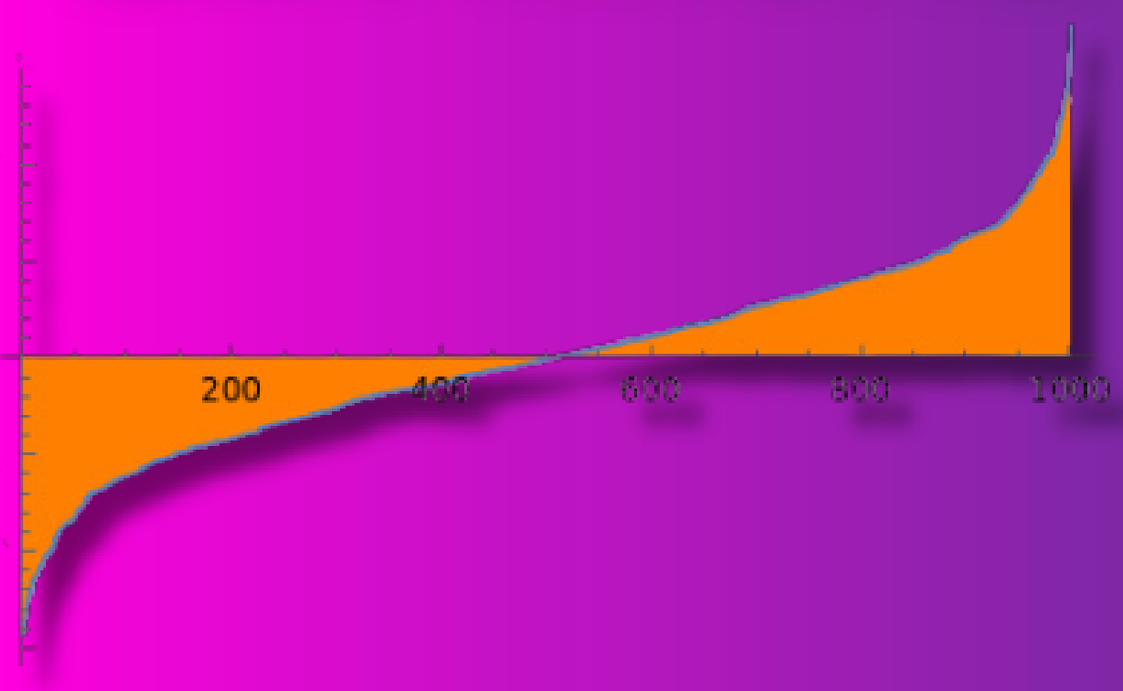
DISTRIBUTION TYPES

NON-PARAMETRIC

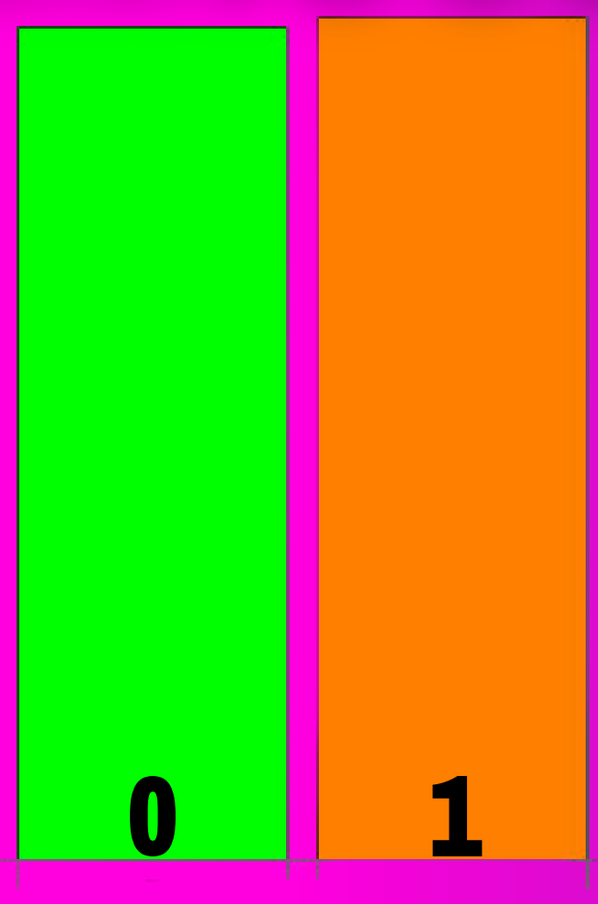
UNIFORM



EMPIRICAL



BERNOULLI

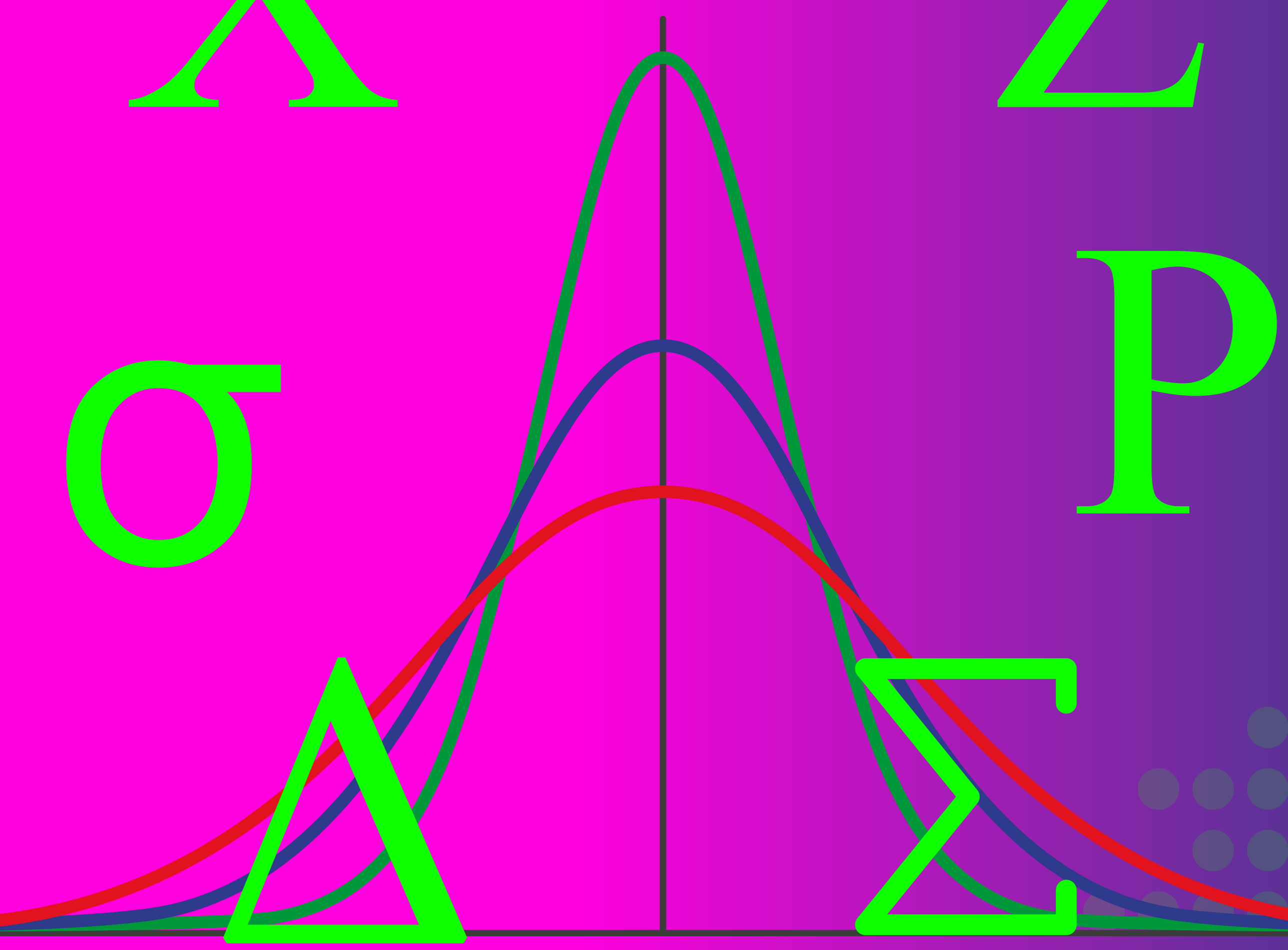


NON-PARAMETRIC DISTRIBUTIONS

UNIFORM	**Probability distribution where all outcomes or values within a given range have an equal probability of occurring.**
EMPIRACLE	**Based on observed data rather than being derived from a known mathematical formula.**
BERNOULLI	**Discrete probability distribution representing a random experiment with only two possible outcomes, typically denoted as success (1) or failure (0), each with a fixed probability.**

STATISTICAL TESTS

χ λ Z



σ p

T-TEST

PURPOSE	Compares the means of two groups
WHEN TO USE IT	Two related groups to compare
DISTRIBUTION	Normal
DATA TYPE	Continuous
WHAT IT SHOWS	If there is a significant differences between group means

T-TEST OUTPUT

```
Independent t-test
------------------
Group 1: Treatment A (n = 30)
Group 2: Treatment B (n = 35)

Test Statistic: t =-2.54
Degrees of Freedom: df = 63
p-value: p = 0.014
```

Test Statistic	**The t-value is calculated based on the difference in means between the two groups and the variability within the groups.**
Degrees of Freedom	**The number of independent pieces of information available to estimate the population parameter.**
p-value	**Probability of obtaining the observed difference (or a more extreme difference) between the groups by chance alone, assuming that the null hypothesis is true (i.e., there is no difference between the groups)**

CHI-SQUARE

PURPOSE	**Test for association between variables**
WHEN TO USE IT	**Assess relationship between categorical variables**
DISTRIBUTION	**No strict distribution requirement**
DATA TYPE	**Categorical**
WHAT IT SHOWS	**Look for significant differences between observed and expected values**





CHI-SQUARE OUTPUT

```
Chi-Square Test of Independence

              |     Group A      |     Group B      |     Group C      |     Group D
--------------|------------------|------------------|------------------|--------------
Observed      |        50        |        45        |        35        |        60
Expected      |        40        |        50        |        30        |        60
--------------|------------------|------------------|------------------|--------------
Total         |       190        |       190        |       190        |       190

Chi-Square Test Statistics
-----------------------------------
Chi-Square Value            |   8.96
Degrees of Freedom          |   3
p-value                     |   0.0304
```

Chi-Square Value	**Measures the discrepancy between the observed and expected frequencies.**
Degrees of Freedom	**The number of categories minus 1**
p-value	**The probability associated with the test statistic. It indicates the level of statistical significance.**

ANOVA

PURPOSE	**Compare means of multiple groups**
WHEN TO USE IT	**Three or more groups**
DISTRIBUTION	**Normally distributed**
DATA TYPE	**Numerical**
WHAT IT SHOWS	**Significant differences between group means**

CHI-SQUARE OUTPUT

```
Analysis of Variance (ANOVA)
-------------------------------------------------------------------------------
Source          |    Sum of Squares  |  Degrees of Freedom |  Mean Square |  F Value |    p-value
-------------------------------------------------------------------------------
Between Groups  |       45.12        |          2          |     22.56    |   3.74   |    0.031
-------------------------------------------------------------------------------
Within Groups   |       126.48       |          27         |     4.69     |
-------------------------------------------------------------------------------
Total           |       171.60       |          29         |
-------------------------------------------------------------------------------

Chi-Square Value              |   8.96
Degrees of Freedom            |   3
p-value                       |   0.0304
```

Between Groups	**Information about the variation between the different groups being compared.**
Within Groups	**Information about the variation within each group.**
Total	**Overall sum of squares and degrees of freedom for the entire dataset, combining the between and within group variations.**

REGRESSION

PURPOSE	**Examine relationships between variables**
WHEN TO USE IT	**Predict the value of a dependent variable**
DISTRIBUTION	**No strict distribution requirement**
DATA TYPE	**Numerical**
WHAT IT SHOWS	**Assess the strength and significance of relationships**





REGRESSION OUTPUT

```
==============================================================================
                 Coefficient    Standard Error    t-value     p-va
------------------------------------------------------------------------------
ntercept          12.345          0.678          18.154     <0.001
_Variable          0.987          0.043          22.885     <0.001
------------------------------------------------------------------------------
```

Regression Equation	**Y = 12.345 + 0.987 * X_Variable**
Coefficients	• **The intercept (12.345) represents the estimated value of the dependent variable when the independent variable (X_Variable) is zero.** • **The coefficient for X_Variable (0.987) represents the estimated change in the dependent variable for a one-unit increase in X_Variable.**
R-Square	**Proportion of the variance in the dependent variable that is explained by the independent variables.**
p-value	**Statistical significance of a coefficient.**

Mann-Whitney U Test

PURPOSE	**Compare distributions of two groups**
WHEN TO USE IT	**Compare distributions of two independent groups**
DISTRIBUTION	**No strict distribution requirement**
DATA TYPE	**Numerical/Ordinal**
WHAT IT SHOWS	**Significant differences in rank order**

MANN-WHITNEY

OUTPUT

```
Mann-Whitney U Test Results:
------------------------------------------
U Statistic: 1234.5
p-value: 0.0234
```

U Statistic	**Rank-based test statistic used in the Mann-Whitney U test. It quantifies the degree of difference between the two groups.**
p-value	**Statistical significance of the test. It indicates the probability of obtaining the observed difference between the groups if there were no true differences in the populations from which the samples were drawn.**

Kruskal-Wallis

PURPOSE	**Compare distributions of multiple groups**
WHEN TO USE IT	**Compare distributions of three or more independent groups**
DISTRIBUTION	**No strict distribution requirement**
DATA TYPE	**Numerical/Ordinal**
WHAT IT SHOWS	**Look for significant differences in rank order**

Kruskal-Wallis Output

```
Kruskal-Wallis Test

H = 12.45
df = 2
p-value = 0.0023
```

H	Sum of ranks across all groups and is used to assess the differences between the groups.
Degrees of Freedom	Number of groups minus 1
p-value	Strength of evidence against the null hypothesis (the assumption that there are no differences between the groups).

Pearson's Correlation

PURPOSE	Measure the strength of linear relationship
WHEN TO USE IT	Assess the strength and direction of a linear relationship
DISTRIBUTION	Normally distributed
DATA TYPE	Numerical
WHAT IT SHOWS	Look for correlation coefficient and its significance





Pearson's Correlation Output

```
Correlation Coefficient (r): 0.85
p-value: < 0.001
Sample Size (n): 100
p-value = 0.0023
```

Correlation Coefficient (r)	**Strength and direction of the linear relationship between the variables. It ranges from -1 to +1. A positive value indicates a positive correlation, a negative value indicates a negative correlation, and a value close to zero indicates a weak or no correlation.**
p-value	**Probability of observing the given correlation coefficient by chance.**
Sample Size (n)	**Number of data points used to calculate the correlation coefficient.**

Spearman's Correlation

PURPOSE	Measure the strength of monotonic relationship
WHEN TO USE IT	Assess the strength and direction of a monotonic relationship
DISTRIBUTION	No strict distribution requirement
DATA TYPE	Numerical/Ordinal
WHAT IT SHOWS	Look for correlation coefficient and its significance

Spearman's Correlation Output

```
Spearman's Rank-Order Correlation Test:
----------------------------------------
Correlation-0.732
p-0.002
Sample-50
```

Correlation Coefficient (r)	**Strength and direction of the linear relationship between the variables. It ranges from -1 to +1. A positive value indicates a positive correlation, a negative value indicates a negative correlation, and a value close to zero indicates a weak or no correlation.**
p-value	**Probability of observing the given correlation coefficient by chance.**
Sample Size (n)	**Number of data points used to calculate the correlation coefficient.**

One-Sample T-Test

PURPOSE	**Compare sample mean to a known population mean**
WHEN TO USE IT	**Compare a sample mean to a known value**
DISTRIBUTION	**Normally distributed**
DATA TYPE	**Numerical**
WHAT IT SHOWS	**Look for significant differences between the sample mean and the known population mean**

One Sample T-Test Output

```
One-Sample t-Test

Variable: SampleData
Sample Mean: 25.6
Population Mean: 30.0
Sample Size: 50
Degrees of Freedom: 49
t-Statistic: -2.345
p-value: 0.023
```

t-statistic	**Difference between the sample mean and the hypothesized population mean in terms of standard errors**
p-value	**Probability of obtaining the observed difference (or a more extreme difference) between the sample and the hypothesized population by chance alone.**
Sample Size (n)	**Number of data points used to calculate the correlation coefficient.**

Wilcoxon Signed-Rank

PURPOSE	**Compare paired samples**
WHEN TO USE IT	**Compare paired observations**
DISTRIBUTION	**No strict distribution requirement**
DATA TYPE	**Numerical/Ordinal**
WHAT IT SHOWS	**Look for significant differences between paired observations**

Wilcoxon Signed-Rank Output

```
Wilcoxon Signed-Rank Test

data:  x
V = 45, p-value = 0.028
alternative hypothesis: true location is not equal to 0
```

V	Summarizes the data and is used to assess the statistical significance of the test.
p-value	Statistical significance of the test