**Statistical Testing Framework – Built using OPAIR**

**O - Objective**

Enable analysts, researchers, and decision-makers to confidently select, apply, and communicate the right statistical test for their data scenario, ensuring results are valid, interpretable, and decision-ready.

**P - Principles**

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| **Principle** | **Description** |
| **Data-Driven Decision Making** | Selection based on data type, sample structure, and test assumptions—not habit or convenience. |
| **Match Method to Question** | The statistical method must answer the actual analytical question at hand. |
| **Validate Assumptions** | Check normality, variance equality, and independence before committing to a parametric method. |
| **Prefer Simplicity** | Choose the simplest test that meets assumptions—avoid overcomplication. |
| **Offer Robust Alternatives** | Use non-parametric tests or bootstrapping when assumptions fail. |
| **Visualize to Clarify** | Use appropriate, high-impact visuals to make findings intuitive and actionable. |

**A - Actions**

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| **Functionality** | **Description** |
| **Guide Test Selection** | Matches problem type to test via structured rules. |
| **Surface Assumptions** | Clearly states what must be true for the test to be valid. |
| **Suggest Alternatives** | Offers viable non-parametric or robust options. |
| **Prompt for Missing Inputs** | Ensures critical information is collected before selection. |
| **Recommend Visualizations** | Suggests best-fit visual formats for results. |
| **Aid Interpretation** | Encourages reporting of effect sizes, confidence intervals, and practical significance—not just p-values. |

**I - Inputs**

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| **Input Type** | **Why It Matters** |
| Objective of Analysis | Clarifies whether the goal is comparison, association, or prediction. |
| Variable Types | Determines eligible tests (categorical, continuous, ordinal, binary). |
| Number of Groups/Samples | Affects test type (paired vs. independent). |
| Sample Size | Influences statistical power and test validity. |
| Normality Status | Needed for parametric test eligibility. |
| Equality of Variance | Relevant for many mean-comparison tests. |
| Measurement Level | Nominal, ordinal, interval, ratio—affects test choice. |
| Visual Preferences | Shapes the communication method for results. |

**R - Real-World Examples**

### **Example 1:**

* **Objective**: Evaluate impact of training on employee test scores
* **Design**: Paired (same employees pre- and post-training)
* **Variables**: Continuous
* **Test**: Paired t-Test
* **Assumptions**: Normality confirmed (Shapiro-Wilk)
* **Visuals**: Side-by-side boxplots with CI overlays + slope lines for individual changes
* **Narrative Insight**: "Most employees improved. The mean increase was statistically significant (p < 0.05), with a large effect size (Cohen’s d = 0.8), suggesting the training had substantial impact."

### **Example 2:**

* **Scenario**: School tests math performance before and after new teaching method.
* **Framework Application**:
  + Objective: Pre/post comparison
  + Variables: Continuous
  + Design: Paired
  + Test: Paired t-Test
  + Assumptions: Normality confirmed
  + Visuals: Line plot, Boxplot + CI, Effect size plot

**Red Flags to Watch For**

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| **Red Flag** | **Risk** |
| Using parametric tests without testing assumptions | May invalidate results |
| Ignoring variable type | Leads to incorrect test selection |
| Relying solely on p-values | Misses practical significance |
| Skipping effect size or CI | Reduces interpretability |
| Overcomplicating analysis | Confuses stakeholders and delays decisions |

**Test Selector Matrix**

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| --- | --- | --- | --- | --- |
| **Problem Type** | **Data Structure** | **Recommended Test** | **Key Assumptions** | **Suggested Visuals** |
| One sample mean | One sample, continuous | One-sample t-Test | Normality | Histogram, Dot Plot, CI Plot |
| Two means (independent) | Two independent groups | Independent t-Test | Normality, equal variances | Boxplot, Bar+CI, Violin |
| Two means (paired) | Paired samples | Paired t-Test | Normality | Line Plot, Boxplot, CI Change |
| Three+ means (independent) | 3+ groups | One-way ANOVA | Normality, equal variances | Violin Plot, ANOVA Plot |
| Three+ means (paired) | Repeated measures | Repeated Measures ANOVA | Normality | Raincloud Plot, Line Graph |
| Variance comparison | Two samples | F-Test | Normality | Density Plot, Spread Chart |
| Continuous relationship | Two continuous vars | Pearson Correlation | Linearity, normality | Scatterplot, Corr Heatmap |
| Categorical relationship | Two categorical vars | Chi-Square Test | Expected cell counts | Mosaic Plot, Grouped Bars |
| Proportion test | Observed vs expected | Z-Test for Proportions | Large n | Proportion Bars, Donut Chart |
| Goodness of fit | Observed vs expected dist. | Chi-Square GoF | Expected frequencies | Stacked Bar, Deviation Plot |

**Summary**

This OPAIR-aligned framework ensures the right test is selected every time, supported by data structure, statistical assumptions, and meaningful visuals. By elevating clarity, rigor, and interpretability, it transforms statistical testing from an intimidating hurdle to a strategic asset for data-informed decisions.