

Understanding Partial Eta Squared: A Guide to Effect Size in ANOVA

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November 5, 2025

RECOMMENDED CITATION

Mohammed loot (2025). *Understanding Partial Eta Squared: A Guide to Effect Size in ANOVA*. PSYCHOLOGICAL STATISTICS. Retrieved from <https://statistics.arabpsychology.com/?p=10766>

The measurement of impact is central to empirical research. In statistical analysis, particularly when using the Analysis of Variance ([ANOVA](#)) framework, researchers require a robust metric to quantify how strongly independent variables influence outcomes. This is where [Partial eta squared](#) (η_p^2) proves indispensable.

Partial eta squared serves as a highly effective estimate of the [effect size](#). It represents the proportion of variance in the dependent variable that is uniquely associated with a specific factor or interaction term within the model. Crucially, unlike some other variance metrics, partial eta squared isolates the variance attributable to the factor of interest relative only to the variance that factor could potentially explain, effectively controlling for the variance explained by other independent variables in the design. This isolation makes it a preferred measure in complex multivariate designs.

Understanding the Calculation of Partial Eta Squared

To calculate partial eta squared, researchers must extract specific components from their [ANOVA](#) output table. The core conceptual framework relies on partitioning the total variance into components explained by the model effects and the remaining error. Partial eta squared focuses specifically on the ratio between the variance explained by the targeted effect and the sum of that variance plus the residual error variance.

The calculation isolates the contribution of a single factor, making it easier to interpret its independent influence regardless of how many other predictors are included in the overall statistical model. This characteristic enhances the clarity of reporting findings in multi-factor designs.

The standardized formula utilized for this calculation is straightforward:

$$\text{Partial eta squared } (\eta_p^2) = \text{SSeffect} / (\text{SSeffect} + \text{SSerror})$$

The components necessary for this calculation are defined as follows:

SSeffect: This is the [Sum of Squares](#) (SS) specifically attributed to the independent variable, main effect, or interaction term currently being examined. It quantifies the variation explained by that factor.

SSerror: This represents the residual Sum of Squares, which is the unexplained variance or the error term remaining after accounting for all the effects included in the ANOVA model.

Interpreting the final value is critical. Since it represents a proportion of variance, the resulting partial eta squared value is always bounded between 0 and 1. A value approaching 1 signifies that the variable accounts for nearly all the non-error variance in the outcome measure, suggesting a powerful effect. Conversely, a value close to 0 indicates a negligible contribution from that variable.

to explaining the outcome variability.

Interpreting the Magnitude: Cohen's Guidelines

While the formula provides the raw value, its true meaning is often judged against established conventional guidelines for interpreting the magnitude of the [effect size](#). These guidelines, notably popularized by Jacob Cohen (1988), provide essential benchmarks for determining the practical significance of research findings.

Using Cohen's criteria helps researchers move beyond statistical significance (p-values) to evaluate whether an effect is meaningful in a real-world context. These established benchmarks are vital for comparative analysis across different studies and disciplines.

The conventional guidelines for interpreting partial eta squared (η_p^2) are:

.01: This threshold suggests a **small effect size**. The independent variable has a detectable but minor impact on the dependent measure.

.06: This marks a **medium effect size**. The variable demonstrates a moderate and noticeable relationship, indicating a reasonably important finding.

.14 or higher: This range signifies a **large effect size**. The variable is responsible for accounting for a substantial amount of the variance in the outcome, suggesting a very strong relationship.

Practical Example: Applying the Formula in a Two-Way ANOVA

To illustrate the calculation, consider a hypothetical research study investigating how two independent variables--exercise intensity (three levels: None, Light, Intense) and biological sex (two levels: Male, Female)--influence the dependent variable, weight loss (measured in kilograms). The study enrolls 60 participants, balanced equally across all conditions over a month-long intervention.

Since this design involves two factors, the statistical analysis utilizes a two-way [ANOVA](#). The summary output below provides the necessary [Sum of Squares](#) (SS) values required for calculating partial eta squared for each main effect. Note that the SS values quantify the total variability associated with each component.

	Df	Sum Sq	Mean Sq	F value	p value
gender	1	15.8	15.80	9.916	0.00263
exercise	2	505.6	252.78	158.610	0.00000
Residuals	56	89.2	1.59		

We must apply the partial eta squared formula: $SS_{\text{effect}} / (SS_{\text{effect}} + SS_{\text{error}})$. From the output

table, the SS for the error term (Residuals) is 89.2. We can now calculate the effect size for both the 'gender' and 'exercise' factors:

Partial eta squared for gender: $15.8 / (15.8 + 89.2) = \mathbf{0.15044}$

Partial eta squared for exercise: $505.6 / (505.6 + 89.2) = \mathbf{0.85008}$

The interpretation of these results provides clear insight into the relative importance of the factors. The partial eta squared for exercise (0.85) is exceptionally large, suggesting that exercise intensity dominates the prediction of weight loss in this study. The effect of gender (0.15) is also substantial, falling just above the Cohen's threshold for a large [effect size](#) (0.14). This strong disparity in effect size is fully consistent with the highly significant p-value observed for exercise (0.00000) compared to the less extreme, though still significant, p-value for gender (0.00263).

Distinguishing Partial Eta Squared from Standard Eta Squared

It is essential for researchers to understand the subtle but significant statistical difference between partial eta squared (η_p^2) and its related metric, [Eta Squared](#) (η^2). While both measure the proportion of variance explained by a predictor, they differ fundamentally in their denominator.

Standard Eta Squared measures the overall proportion of the **total variance** in the dependent variable explained by a predictor variable within the [ANOVA](#) model. Its calculation incorporates the entire variance observed in the dataset (SS_{total}) as its denominator.

The calculation for Eta Squared is structurally simpler:

Eta squared (η^2) = SS_{effect} / SS_{total}

Where the components are defined as:

SS_{effect}: The Sum of Squares associated with the effect being evaluated.

SS_{total}: The total Sum of Squares across all sources of variance in the model, encompassing all main effects, interaction effects, and the error term.

The key difference lies in what is excluded from the denominator. Partial eta squared effectively removes the variance associated with other factors (other main effects and interactions) from the denominator, focusing only on the variance shared between the effect and the residual error. Standard Eta Squared, conversely, includes the variance explained by all other factors in its denominator (as they contribute to SS_{total}). Consequently, in models with multiple predictors (e.g., two-way or N-way ANOVA), partial eta squared is generally preferred because it provides a measure specific to the effect of interest, independent of the influence of other factors included in the design. This makes it a purer measure of the unique contribution of that variable.

It is worth noting an important exception: for a simple one-way ANOVA, which only contains a single predictor variable, the variance explained by "other effects" is zero. Therefore, the values for Eta Squared and Partial Eta Squared will be mathematically identical. Due to common practice and standardization in multivariate analysis, statistical software packages like SPSS typically report the partial eta squared value by default, underscoring the necessity for researchers to grasp these subtle yet crucial methodological distinctions.

Conclusion and Further Exploration

Partial eta squared is recognized as a robust and essential measure of [effect size](#) in the behavioral and social sciences, proving especially valuable in complex ANOVA designs where the goal is to isolate the unique impact of specific variables. Mastering its calculation and interpretation, particularly in comparison to standard eta squared, is fundamental for accurately reporting statistical findings and communicating the practical significance of research results.

For those seeking to deepen their understanding of advanced statistical reporting or explore alternative effect size measures (such as generalized eta squared or omega squared), further reading into multivariate statistics and research methodology is highly recommended.