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A Summary of MANOVA and GLM

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**What is it?**

is the multivariate extension of the univariate techniques for assessing the differences between group means.  In contrast to ANOVA, it can examine more than one dependent variable at the same time. In a single dependent measure is tested for equality across the groups.   In the multivariate case, a variate is tested for equality.  In MANOVA, the researcher actually has two variate – one for the dependent variables and another for the independent variables.  The dependent variable variate is of more interest because the metric-dependent measures can be combined in a linear combination, as we have already seen in multiple regression and discriminant analysis.  The unique aspect of MANOVA is that the variate optimally combines the multiple dependent measures into a single value that maximizes the differences across groups.

**What is it used for?**

MANOVA can be broken down into two different goals.

1. To analyze a dependence relationship represented as the differences in a set of dependent measures across a series of groups formed by one or more categorical independent measures.

2. To provide insights into the nature and predictive power of the independent measures as well as the interrelationships and differences in the multiple dependent measures.

**Differences in MANOVA and Discriminant Analysis.**

The discriminant analysis employs a single nonmetric variable as the dependent variable. The categories of the dependent variable are assumed as given, and the independent variables are used to form variates that maximally differ between the groups formed by the categories of the dependent variable.

MANOVA uses the set of metric variables as dependent variables and the objective becomes finding groups of respondents that exhibit differences on the set of dependent variables. The groups of respondents are not prespecified; instead, the researcher uses one or more independents variables (nonmetric variables) to form groups. MANOVA, even while forming these groups, still retains the ability to assess the impact of each nonmetric variable separately.

**Sample size**

As a bare minimum, the sample in each cell group must be greater than the number of dependent variables.  As a practical guide, a recommended minimum cell size is 20 observations.  However, quality over quantity is encouraged. Additionally, as the number of dependent variables increases, the sample size required to maintain statistical power increases as well.

**Normality**

A multivariate normal distribution assumes that the joint effect of two variables is normally distributed. Even though this assumption underlies most multivariate techniques, no direct test is available for multivariate normality.

For the multivariate test procedures used with MANOVA to be valid:

-Observations must be independent.

-Variance-covariance matrices must be equal (or comparable) for all treatment groups.

-The dependent variables must have a multivariate normal distribution.

-Multivariate normality is assumed, but many times hard to assess.  Univariate normality does not guarantee multivariate normality, but if all variables meet the univariate normality requirement then departures from multivariate normality are inconsequential.

ANOVA F-tests are generally robust if violations of these assumptions are modest.

**Statistical Power of the Multivariate Test**

In Simple terms of MANOVA, power is the probability that a statistical test will identify a treatment effect if it actually exist.  Power can also express as one number the probability of a TYPE II ERROR or Beta(B) error (i.e., Power = 1-B).  Roy’s gcr is a more powerful test statistic if the researcher is confident that all assumptions are strictly met and the dependent measures are representative of a single dimension of effects. In a vast majority of situations, all of the statistical measures provide similar conclusions. Lastly, When faced with conflicting conditions, however, statistical measures can be selected that meet the situation faced by the researcher.

**Interpreting Covariates and Interaction Effects**

When covariates are involved in a GLM model: Analyze the model both with and without the covariates. If the covariates do not improve the statistical power or have no effect on the significance of the treatment effects, then they can be dropped from the final analysis. Any time two or more independent variables (treatments) are included in the analysis, interactions must be examined before drawing conclusions about the main effects for any independent variable. If the interactions are not statistically significant, then the main effects can be interpreted directly since the difference between treatments is considered constant across combinations of levels.

If the interaction is statistically significant and the differences are not constant across combinations of levels, then the interaction must be determined to be ordinal or disordinal. Ordinal interactions mean that the direction of differences does not vary by level (e.g., males always less than females) even though the difference between males/females varies by level on the other treatment. In this case, the size of the main effect (e.g., males versus females) should only be described separately for each level of the other treatment. Significant disordinal interactions occur when the direction of an observed main effect changes with the level of another treatment (e.g., males greater than females for one level and less than females for another level). Disordinal interactions interfere with the interpretation of the main effects.

**Interpreting Differences between Individual Groups**

When the independent variable has more than two groups, two types of procedures can be used to isolate the source of differences. Post-hoc tests examine potential statistical differences among all possible combinations of group means.  Post-hoc tests have limited power and thus are best suited to identify large effects. Planned comparisons are appropriate when a priori theoretical reasons suggest that certain groups will differ from another group or other groups.  Type I error is inflated as the number of planned comparisons increases.