

Correlated Error Terms, Nonnormal Data, and Heteroscedasticity

If the independence assumption is violated, tools other than PROC GLM must be used to account for correlated errors. These include PROC MIXED, PROC GLIMMIX, or PROC GENMOD to model repeated measures. For data gathered from a complex survey design, you can use PROC SURVEYREG with a CLASS statement to perform the ANOVA. If the assumption of normality is violated, transformation of the response variable often normalizes the data and an ANOVA can then be conducted on the transformed data. Transformations might also correct unequal variance problems. When appropriate, you can use PROC GENMOD or PROC GLIMMIX with the appropriate distribution and link function to fit a generalized linear model to nonnormal data.

When data is extremely skewed or there are extreme outliers, transformation of the data might not correct the problem. In this case, nonparametric ANOVA might be appropriate. The NPAR1WAY procedure can be used to fit a nonparametric one-way ANOVA. For two-way or higher-ordered nonparametric ANOVA, you might consider ranking your dependent variable and use PROC GLM to perform ANOVA on ranks (Iman 1988 and Iman 1982). However, remember that ANOVA is robust to departures from normality, particularly with a large enough sample size. When variances are unequal, you can use PROC GENMOD, PROC MIXED, or PROC GLIMMIX to model the nonconstant variances. Various approaches are available in these procedures and one, the GROUP= option in PROC GLIMMIX, is shown in a demonstration.

If the variances are unequal and it is a one-way ANOVA, then Welch's variance-weighted ANOVA can be used. It is specifically designed for unequal variance situations. It should be noted, however, that other GLM procedure statements, such as the LSMEANS and CONTRAST statements, are not valid for a Welch ANOVA. You might also use nonparametric ANOVA for this situation. When variances are unequal, another approach is to transform the response variable to stabilize the variances.